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ANTARCTICA, ONE CONTINENT OR TWO?

BY EDWARD THIEL*

[*MS. received 4 October 1960.*]

Naturally in my own field of geological research I find the most intriguing prospects in Antarctica. The greatest problem in structural geology in all the world awaits solution here: namely is the Antarctic continent one great land mass or is it separated into two major parts by a great trough-like connection between the Ross and Weddell Seas?

LAWRENCE M. GOULD, 1931

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[Place names which have not yet been approved by the United Kingdom Antarctic Place Names Committee are placed in quotes—Ed.]

The problem

In outline, the Antarctic continent crudely resembles a pear. It is indented on two sides by arms of the ocean, the Ross and Weddell Seas. These indentations are even greater than an outline map would suggest, for the seas extend far toward the interior of the continent beneath the world's two largest floating ice shelves, bearing the names of their respective discoverers, the English sea captain, Ross, and the German explorer, Filchner.

Geographers for decades have found it expedient to distinguish between the two parts of the continent. The dividing line has usually been taken as the 0°–180° meridian. That part of the continent lying on the Asiatic side of this line has been designated "East Antarctica" because all points within it require the designation "degrees East" when specifying their longitude. Analogously that part of the continent on the American side of the line is "West Antarctica". This nomenclature has been criticized for several reasons.[1] In the present paper we shall use the terms "Lesser Antarctica" and "Greater Antarctica". "Lesser Antarctica" designates the top of the pear. It includes the Palmer Peninsula (Graham Land), the Ross Ice Shelf, the Filchner Ice Shelf, and the intervening grounded ice areas of Marie Byrd Land and Ellsworth Highland. "Greater Antarctica" designates the bottom of the pear. It includes the greater part of the continent, and is largely high plateau. The demarcation line lies on the Pacific Ocean side of the mountains which extend across the continent from Cape Adare to Coats Land; the mountains

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themselves lie in "Greater Antarctica". This division has multiple significance: in a physiographic sense it separates a high ice plateau from an outlying region of ice-covered mountains and floating ice shelves; in a geological sense it separates a Precambrian Shield with its overlapping Palaeozoic sediments from a younger, more recently deformed, area; and in a topographic sense the boundary is drawn at the foot of a mountain system and it follows a topographic low separating two high parts of the Antarctic ice sheet.

From the time that the crude pear-shaped form of the Antarctic continent was first perceived, geographers have pondered the gross structure. The early explorers reached the region by ship, and, discovering the two indenting seas with great ice shelves at their heads, suggested that a continuous strait connected the seas to create in fact two continents. This was speculation, for before 1900 no explorer was able to penetrate the interior of Antarctica. The successful conquest of the South Pole by Amundsen and Scott showed that the Ross Ice Shelf did indeed extend far into the interior, but left open the question of the solidarity of the continent. The aerial explorations of Admiral Byrd eliminated the possibility that the Ross and Filchner Ice Shelves were continuous by the discovery of intervening ice at higher elevations. This aerial reconnaissance could not eliminate the possibility that the rock floor was everywhere below sea level; for this an extensive programme involving seismic soundings of ice thickness was necessary. The questions which intrigued geographers were clearly put by Sir Douglas Mawson[2]

> Is it one continuous rocky land above sea level, merely veneered by ice? Is it a number of isolated epicontinental islands which have been overwhelmed and united by a flood of glacier ice and between which the sea would flow were the ice to melt? In the latter case, are the inter-island channels choked to the very bottom with glacier ice so that the ice rides on a rock bottom below sea level? Or does the sea water, in some at least of these, maintain a through-flow deep down under the capping ice so that the inter-island ice caps, though very thick and of land origin, are yet afloat on sea water?

Investigations

The locations of United States ground and airlifted traverses in "Lesser Antarctica" since the inception of the International Geophysical Year programme are indicated in Fig. 1 and Table 1. With the exception of a traverse across the eastern part of the Filchner Ice Shelf by the British Commonwealth Trans-Antarctic Expedition, no other traverses involving seismic measurements have been conducted in "Lesser Antarctica". A traverse for the 1960–61 season is under way from "Byrd" to the Bellingshausen Sea coast, but results are not yet available.

1957–58: exploration of the Filchner Ice Shelf

The first over-snow traverse to bear directly on the question "One continent or two?" set out from "Ellsworth" in October 1957 by Sno-cat to explore the interior of the Filchner Ice Shelf. A brief account of the geographical results of this work, written shortly after the party returned from the field and before all the data could be interpreted, has appeared.[3] The results were of particular

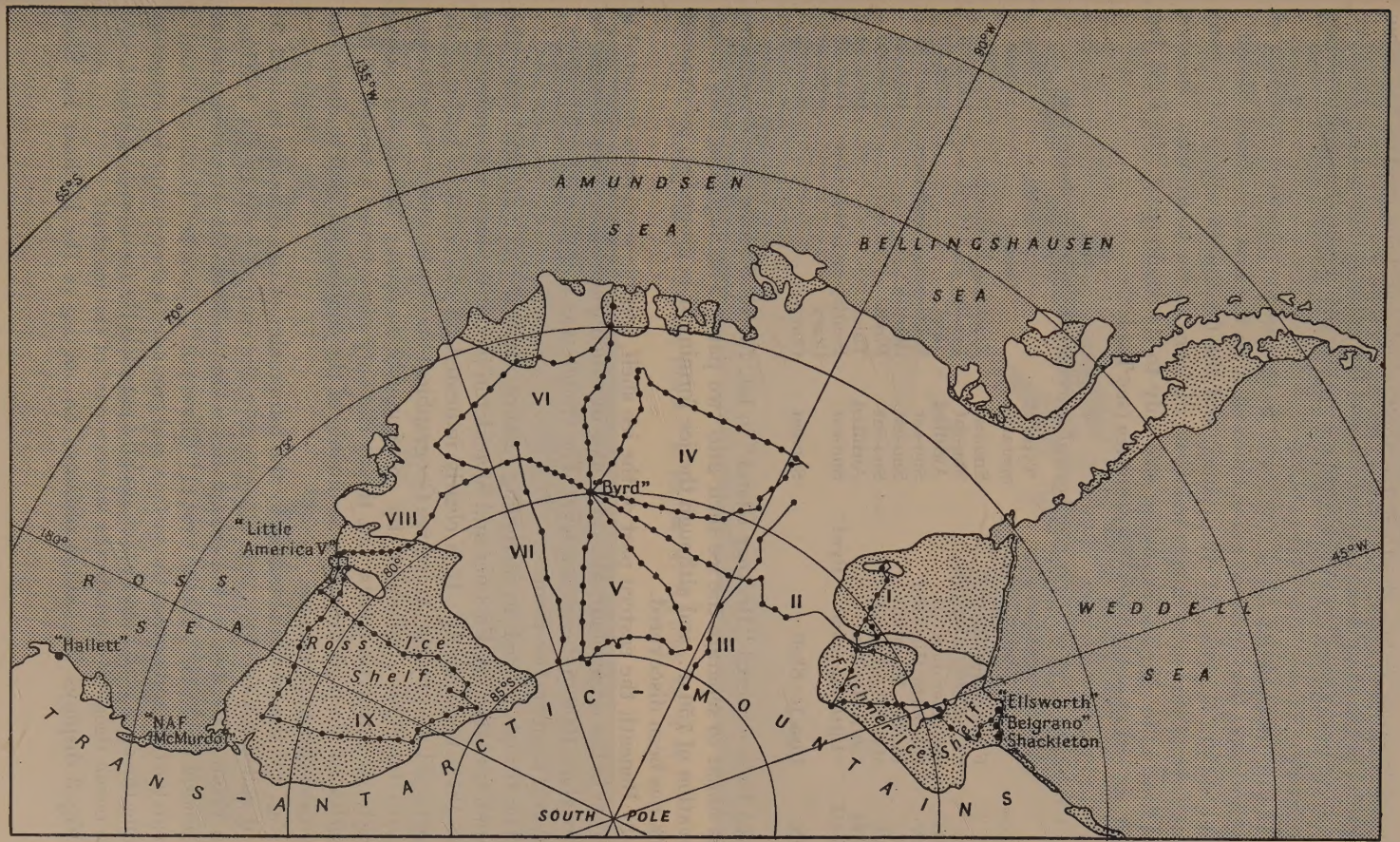

Fig. 1. United States geophysical traverses in "Lesser Antarctica".

interest because, unlike the Ross Ice Shelf which had been explored in some detail by Scott, Shackleton, Amundsen and Byrd, the interior of the Filchner Ice Shelf was entirely unknown. Three important geographical discoveries were made.

(1) The Filchner Ice Shelf was found to extend far toward the interior of the continent. The traverse party followed it to the foot of "Dufek Massif" in lat. 82° 30′ S., long. 52° W. (centre) and the floating ice appeared to continue beyond this point for an unknown distance to the south-west. In area this floating ice shelf is second in size only to its counterpart, the Ross Ice Shelf, on the opposite side of Antarctica (see Table 2).

Table 1. *United States geophysical traverses in "Lesser Antarctica"*

Key	Traverse	Type of operation	Leader	Season
I	Filchner Ice Shelf	Sno-cat	Thiel and Neuburg	1957–58
II	"Ellsworth"–"Byrd"	Sno-cat	Bradley and Pirrit	1958–59
III	88th Meridian	Airlifted	Thiel	1959–60
IV	Ellsworth Highland	Sno-cat	Bentley and Anderson	1957–58
V	Horlick Mountain	Sno-cat	Bentley	1958–59
VI	Marie Byrd Land	Sno-cat	Pirrit	1959–60
VII	130th Meridian	Airlifted	Thiel	1958–59
VIII	"Little America"–"Byrd"	Sno-cat	Bentley and Anderson	1956–57
			Crary	1957–58
IX	Ross Ice Shelf	Sno-cat	Crary	1957–58

(2) Snow-covered "Berkner Island" in lat. 79° 20′ S., long. 48° W. (centre) was found to separate the ice shelf into two parts. This highland rises to an elevation of 750 m., and although the ice forming it is grounded, no exposed rock has been discovered.

(3) Beneath the eastern part of the ice shelf, seismic soundings detected a trough in the ocean floor, along the axis of which the rock surface dropped to more than 1000 m. below sea level. The trough was still present at lat. 82° S., 500 km. from the ice front.

The trough proved an intriguing feature. It had first appeared from the soundings taken by Filchner and Shackleton in the Weddell Sea during 1912 and 1915, respectively. It is clearly indicated on the coloured bathometric chart published by the American Geographical Society in 1930.[4] Today ocean depths have been measured by continuously recording fathometers along nearly all Antarctic coasts, but this is the only place where a trough of this depth cuts through the upper sediments of the continental shelf to disappear beneath the Antarctic ice.

Fig. 2 is the profile obtained by the fathometer of the *Wyandot* in 1956–57 as it sailed for the first time along nearly the entire extent of the Filchner Ice Front. The axis of the trough lies 9 km. west of the Argentine station "General Belgrano". To the west of "Ellsworth", opposite "Berkner Island", ocean bottom approaches the surface, and grounded icebergs impede navigation along the open water lead which usually parallels the continent. Farther west the ocean deepens opposite the western part of the ice shelf.

Fig. 3 displays the section obtained on one leg of the Filchner Ice Shelf

West side of "Mount Pirrit", in lat. 81° 87′ S., long. 86° 3′ W.

The "Wexler Mountains", in lat. 79° 14′ S., long. 83° 4′ W., looking eastwards near the north-east end of the range. The mountains continue for many miles to the south-east

(*Facing p.* 338)

The eastern Horlick Mountains, in lat. 85° 17′ S., long. 89° W. The view is to the north-west, and the aircraft is ascending one of the small glaciers which separate massifs. Ice drainage is from the high plateau, out of sight to the left, towards the low lying region in the right-centre; the ice drop is 200 m. in this descent

"Stewart Hills", in lat. 84° 15′ S., long. 86° 2′ W., looking eastward. The rocks of the dark outcrop near the centre of the photograph are isoclinically folded. The dark area on the left is not bedrock, but loose boulders resting on blue ice

traverse. The trough at the foot of "Dufek Massif" is evident. The water beneath the western part of the Filchner Ice Shelf is shallow, and two regions of grounded ice were encountered along the traverse route.

The great interior extent of the Filchner Ice Shelf, and of the trough beneath it, reopened the question of the unity of the Antarctic continent, but it was evident that additional field work would be required before an answer could be firmly given.

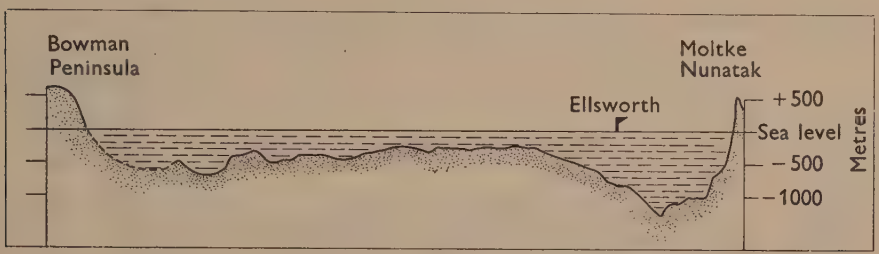

Fig. 2. Fathometer profile of the ocean bottom along the Filchner Ice Front.

Table 2. *Seismic stations, Filchner Ice Shelf traverse, 1957–58*

tation umber	Latitude	Longitude	Elevation (metres)	Reflexion time (seconds)	Ice thickness (metres)	Water thickness (metres)	Rock elevation (metres)
1	77° 42·6′ S.	41° 08′ W.	42	0·9950	231	603	−792
2	78° 05·2′ S.	39° 58′ W.	69	1·1520	466	643	−1040
3	78° 26·8′ S.	39° 13′ W.	72	1·3490	495	772	−1195
4	78° 33·9′ S.	37° 58′ W.	80	1·0860	568	557	−1045
5	78° 53·0′ S.	38° 16′ W.	73	1·1240	505	609	−1041
6	79° 21·2′ S.	40° 25′ W.	86	1·3590	625	732	−1271
7	79° 29·3′ S.	42° 52′ W.	74	No reflexion	515	125	−566
8	79° 27·7′ S.	44° 26′ W.	599	0·3550	676	Grounded	−77
9	79° 52·0′ S.	45° 06′ W.	694	0·4480	853	Grounded	−159
10	80° 35·4′ S.	46° 56′ W.	153	No reflexion	658	Grounded	−505
11	80° 39·7′ S.	47° 09′ W.	81	1·0140	578	501	−998
12	80° 55·6′ S.	47° 59′ W.	96	1·3340	668	698	−1270
13	81° 27·5′ S.	49° 50′ W.	90	1·3820	662	735	−1307
14	82° 10·0′ S.	51° 25′ W.	275	No reflexion	397	Grounded	−122
15	82° 28·9′ S.	52° 17′ W.	523	0·2120	404	Grounded	+119
16	81° 58·5′ S.	54° 45′ W.	129	1·6330	1036	774	−1681
17	81° 30·0′ S.	57° 19′ W.	158	1·2420	1312	388	−1542
18	81° 02·1′ S.	59° 51′ W.	131	0·8660	1046	218	−1133
19	80° 44·3′ S.	62° 19′ W.	224	No reflexion	850	Grounded	−626
20	80° 11·7′ S.	63° 45′ W.	78	No reflexion	550	103	−575
21	79° 54·3′ S.	64° 27′ W.	82	0·4870	587	119	−624
22	79° 28·8′ S.	65° 30′ W.	77	0·4620	542	117	−582
23	78° 58·7′ S.	66° 38′ W.	64	0·4980	422	189	−547
24	78° 49·2′ S.	68° 37′ W.	400	0·3000	572	Grounded	−172
25	80° 14·5′ S.	62° 01′ W.	57	No reflexion	359	76	−378
26	80° 17·0′ S.	60° 28′ W.	162	0·4010	764	Grounded	−602
27	80° 38·2′ S.	58° 17′ W.	105	0·9480	800	370	−1065

Note: At seismic stations where no reflexion was obtained from the bottom of the ice shelf, the ickness of the floating ice was determined from the surface elevation by hydrostatic theory. At ations where no reflexion was obtained from rock, the elevation of the rock surface was computed om gravity measurements.

1958–59: the inland ice sheet

The following season the author returned to Antarctica to lead an airlifted geophysical traverse operating from a ski-equipped DC-3 aircraft. The technique of making a landing at a strategic location, completing the seismic soundings before the aircraft engines had time to cool, and then flying on to

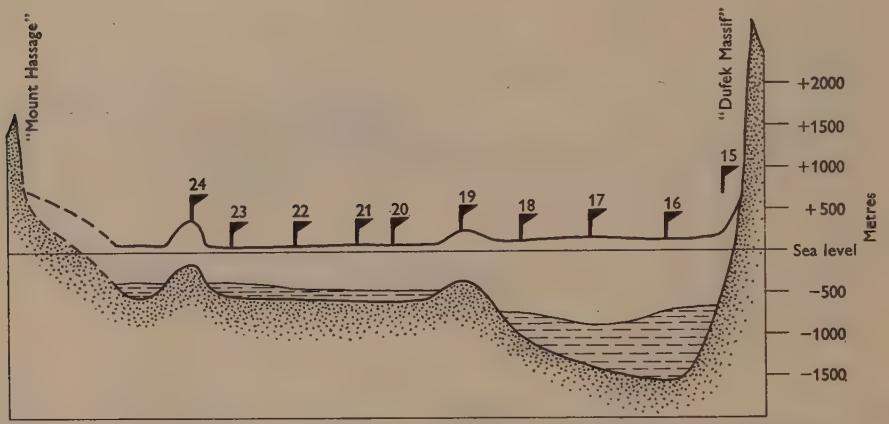

Fig. 3. Seismic section across the Filchner Ice Shelf between "Dufek Massif" and "Mount Hassage" (lat. 77° 30′ S., long. 71° 30′ W.).

Fig. 4. Seismic section of the inland ice sheet along meridian 130° W. between "Mount Petras" (lat. 76° 08′ S., long. 129° 45′ W.) and the "Harold Byrd Mountains" (about lat. 85° 25′ S., long. 146° 30′ W.).

the next site was new in Antarctic geophysics. Logistic considerations dictated that the sites selected for study be not too far from an air facility, and preferably between "Byrd" and "NAF McMurdo" since most search and rescue facilities were based at the latter station. A line was selected across the inland ice sheet along meridian 130° W. (see Fig. 1 and Table 3). The section

obtained from the seismic soundings is presented in Fig. 4. From this work two important conclusions could be drawn.

(1) The inland ice between the Ross and Weddell Seas is grounded, and the possibility of water interchange between the two seas at the present time does not exist.

(2) The rock floor beneath the inland ice over much of the area between the seas is below sea level.

Our question could not yet be resolved because if the ice were to melt, the possibility of water interchange might then exist. These general conclusions were supported by the findings of the Horlick Mountains ground traverse, operating concurrently to the east of the aircraft landing sites.

Table 3. *Seismic stations, 130th meridian airlifted traverse, 1958–59*

Station number	Latitude	Longitude	Elevation (metres)	Reflexion time (seconds)	Ice thickness (metres)	Rock elevation (metres)
1	84° 52′ S.	135° 20′ W.	641	0·7804	1485	−844
2	84° 13′ S.	131° 32′ W.	712	0·8042	1531	−819
3	83° 03′ S.	130° 30′ W.	621	0·7460	1418	−797
4	82° 20′ S.	131° 30′ W.	610	0·8042	1531	−921
5	80° 58′ S.	129° 45′ W.	868	0·6988	1327	−459
6	79° 41′ S.	130° 45′ W.	1139	0·9276	1771	−632
7	78° 08′ S.	130° 45′ W.	1637	0·9810	1874	−237

1959–60: along meridian 88° west

During the IGY programme, United States Navy flyers had made reconnaissance flights over the area to the south-east of "Byrd". They had observed by visual sightings and on radar a number of nunataks in approximate north–south alignment along meridian 88° W. In planning for the first season of post-IGY activity it became evident that it was along this meridian that the question of the unity of Antarctica must be sought, regardless of logistic difficulties and distance from supporting air facilities. The author returned to Antarctica for the third time to lead the airlifted party. There was, however, one important change in the programme; geology was now to be emphasized in place of the glaciological studies which had been made previously on the inland ice sheet. The reasons for this change were compelling. For decades there had been speculation regarding the extension of the folded mountains which form the Palmer Peninsula (Graham Land). Did they simply fan out and disappear as the peninsula met the main mass of the continent? Did they continue as a great mountain range to King Edward VII Land on the eastern margin of the Ross Sea as Charcot had suggested? Or, following the arguments of W. S. Bruce, did they run between the two seas to connect with the mountain ranges of Victoria Land? Clearly, the geology of the nunataks along meridian 88° W. would bear on the overall structure of Antarctica and on the question we had set out to answer.

Fig. 5 is a map of the critical region along meridian 88° W. drawn on the basis of the field investigation. Four landings were made for geological studies —one at the Horlick Mountains at the southern end of the line, one at the

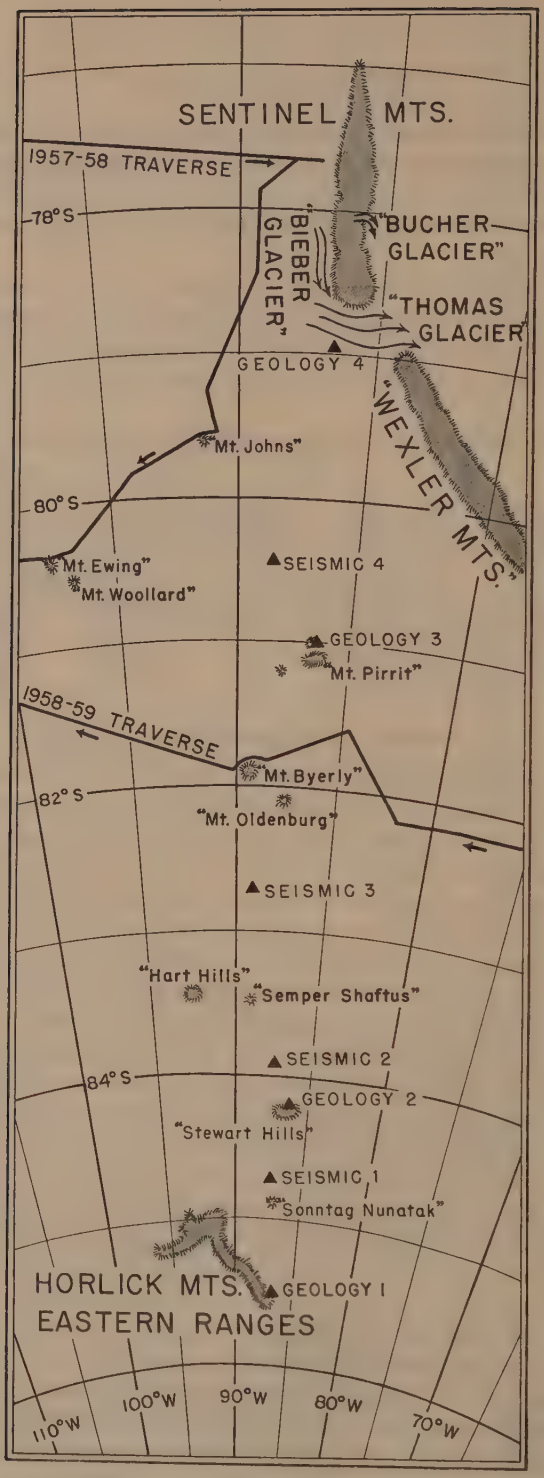

Fig. 5. Map of the highland area of "Lesser Antarctica" along meridian 88° W.

foothills of the impressive Sentinel Mountains (lat. 77° S., long. 80° W., approx.) on the north, and two at intervening nunataks (see Table 4). The outcrops visited by the field party in the eastern Horlick Mountains are monzonite capped by rocks inferred to be sedimentary, but which could not be reached in the time available. The rocks of the western foothills of the Sentinel and "Wexler" Mountains (lat. 79° 40′ S., long. 83° 40′ W.) are metamorphosed sediments, chiefly quartzites and slates, with steep dips and local folding and faulting. The "Stewart Hills" (lat. 84° 15′ S., long. 86° 20′ W.) are also metamorphosed sediments, except that in one location there is pronounced isoclinal folding and the rock is a phyllite. "Mount Pirrit" (lat. 81° 07′ S., long. 86° 30′ W.) is apparently granite. A storm and high winds prevented our reaching the main peak itself, but smaller, outlying outcrops were visited.

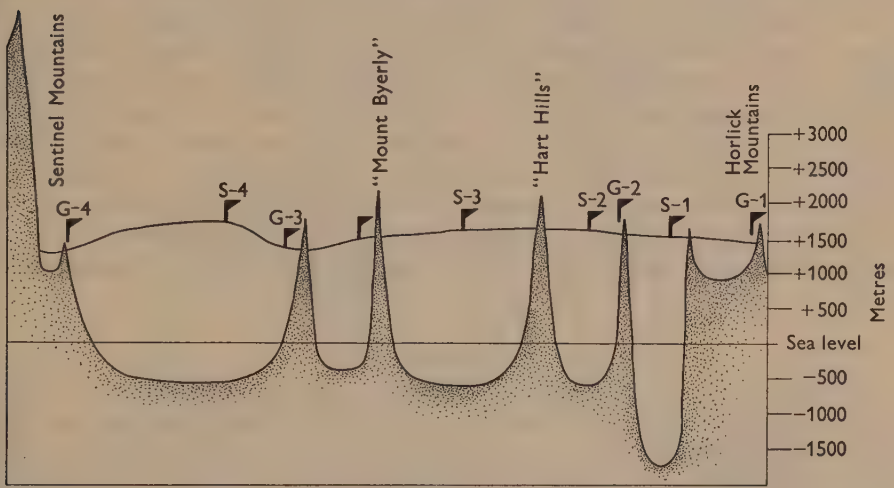

Fig. 6. Seismic section along meridian 88° W. "Mount Byerly" is in lat. 81° 50′ S., long. 89° W. and "Hart Hills" are in lat. 83° 25′ S., long. 93° W.

Table 4. *Landing sites, 88th meridian airlifted traverse, 1959–60*

Station number	Latitude	Longitude	Elevation (metres)	Reflexion time (seconds)	Ice thickness (metres)	Rock elevation (metres)
1	85° 30′ S.	87° 05′ W.	1446	—	0	+1446
2	84° 42′ S.	87° 30′ W.	1543	1·665	3200	−1657
3	84° 12′ S.	86° 25′ W.	1569	—	0	+1569
4	83° 54′ S.	87° 35′ W.	1612	1·1352	2173	−561
5	82° 42′ S.	89° 05′ W.	1606	1·1370	2177	−571
6	81° 00′ S.	86° 30′ W.	1306	—	0	+1306
7	80° 26′ S.	88° 25′ W.	1710	1·1568	2215	−505
8	78° 54′ S.	86° 35′ W.	1303	—	0	+1303

These observations, briefly sketched here but to be reported in detail by the party's geologist, Professor Campbell Craddock, suggest that the eastern part of the Horlick Mountains may be similar to the central part[5] which in turn resembles the other block-faulted and sill-intruded mountains south of the

Ross Ice Shelf. The Sentinel Mountains, "Mount Pirrit", and the "Stewart Hills" have undergone deformation and would seem to belong to another tectonic province. The dividing line apparently lies between the Horlick Mountains and the "Stewart Hills"; it cannot be fixed more precisely from the geological studies because "Sonntag Nunatak" (lat. 84° 50′ S., long. 87° W.) was not visited.

Fig. 6 presents the seismic section. Surprisingly, seismic soundings between rock outcrops indicate that the rock surface drops below sea level at all locations. However, if the ice were to melt and the land to rebound in accord with isostatic theory, the rock at sites S-2, S-3, and S-4 would rise slightly above sea level. Beneath S-1 there would be a water-filled channel, but the maximum width of this channel could not exceed 50 km.

Very clearly the terrain along meridian 88° W. is mountainous, and the results obtained here necessitate a qualifying statement concerning the work along meridian 130° W. and the profile of Fig. 4. There is extensive crevassing along meridian 130° W., and the aircraft landings were of course made in safe areas between crevasse fields. It seems possible that the crevassing occurs over buried mountain peaks, and that the soundings were confined to the deep valleys, although there is no supporting evidence for this suggestion in the relief of the ice surface as measured by the aircraft's radar altimeter. Thus the rock topography might be considerably more rugged than shown in Fig. 4, although the conclusions drawn in previous paragraphs would remain valid.

Conclusions

Three field seasons of geophysical traverse activity now enable us to answer Sir Douglas Mawson's questions for "Lesser Antarctica". The answers are best given diagrammatically in a series of three illustrations. Fig. 7 is a map of the snow surface with a contour interval of 100 m. "Lesser Antarctica" clearly is not a simple snow dome. The surface rises to 2300 m. at two locations, in the vicinity of several small nunataks to the east of "Byrd" and surrounding the Executive Committee Range to the north-west of "Byrd'. Between these two high areas there is a depression where the surface elevation does not exceed 1700 m.

A second depression exists between the Ross and Filchner Ice Shelves, separating the high areas in "Lesser" and "Greater Antarctica".

An additional feature shown in Fig. 7 is the low elevation near the head of the Filchner Ice Shelf. Just to the north of the eastern part of the Horlick Mountains the snow elevation is 1400 m., and to the east of the Sentinel Mountains the radar altimeter recorded an elevation of 400 m. The precise definition of the head of the Filchner Ice Shelf remains unknown, but it is possible that the shelf may be even more extensive than indicated in the illustrations.

Fig. 8 is a map of the ice thickness. The greatest thickness of ice ever recorded lies in mountainous "Lesser Antarctica" 200 km. east of "Byrd". A sounding taken here by Dr Bentley[6] gives a thickness of 4270 m. A number

Fig. 7. Snow surface elevation in "Lesser Antarctica". Contour interval = 100 m. The dots indicate seismic stations used to control the contouring.

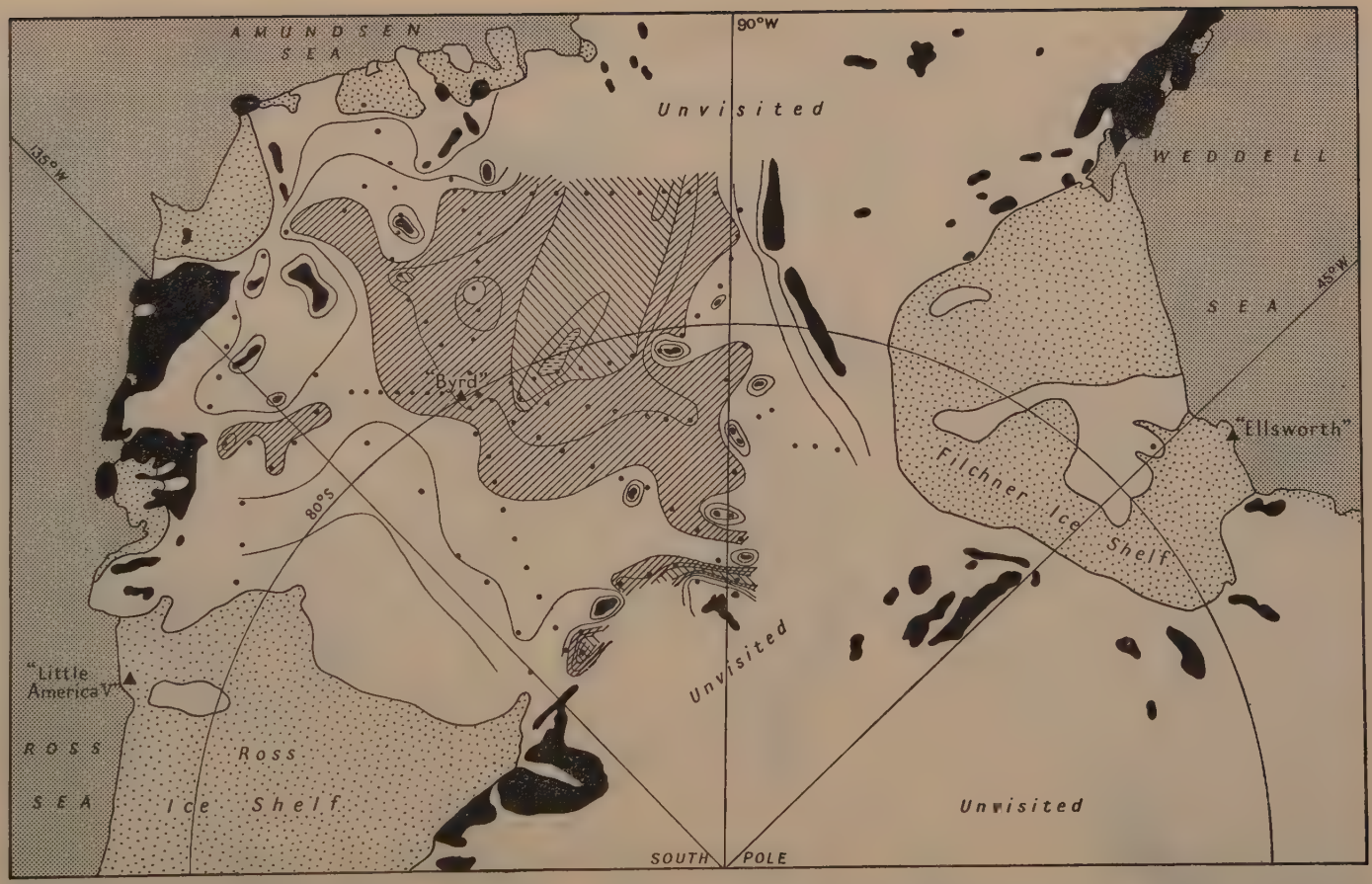

Fig. 8. Ice thickness in "Lesser Antarctica". Contour interval = 500 m. The dots indicate seismic stations used to control the contouring. [▨] : ice thickness between 2000 m. and 3000 m.

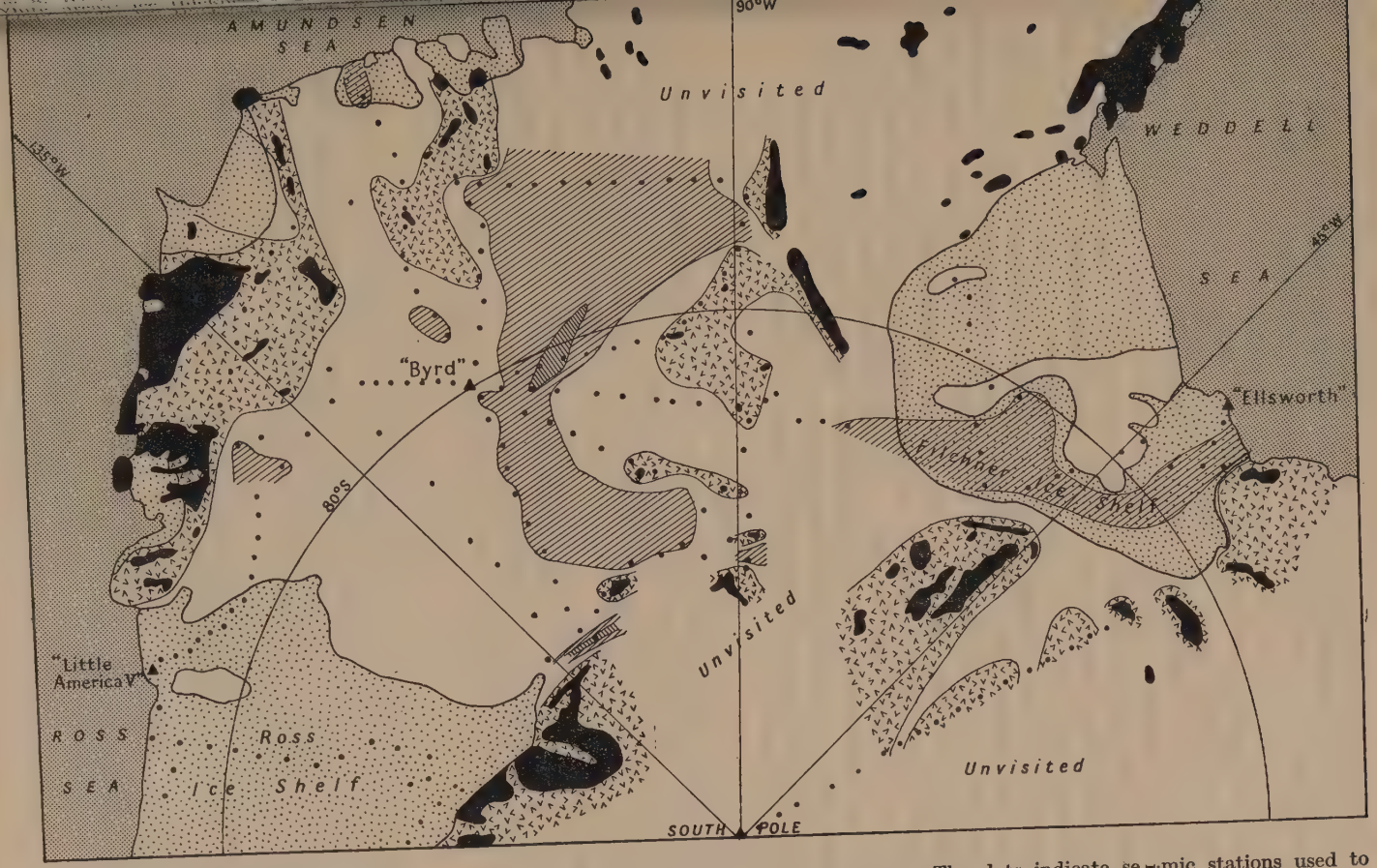

Fig. 9. Elevation of the rock surface in "Lesser Antarctica". Contour interval = 1000 m. The dots indicate seismic stations used to control the contouring. : rock surface above sea level. White areas: rock surface between sea level and −1000 m. (or unvisited). : rock surface between −1000 m. and −2000 m. : rock surface between −2000 m. and −3000 m.

of other soundings suggest a narrow, deep, ice-choked channel along the line of demarcation between "Lesser" and "Greater Antarctica".

Fig. 9 is a generalized map of the elevation of the rock surface in "Lesser Antarctica". The area is divided by a broad ice-filled depression running from the Ross Shelf towards the Amundsen and Bellingshausen Seas. The mountain areas north-west of this depression would be islands were the ice to melt. The trough extending inland from the Weddell Sea is evident, but there is no *broad* connexion between the Ross Sea and the Weddell Sea. A highland area connects "Greater Antarctica" with the base of Palmer Peninsula (Graham Land). Allowing for isostatic rebound, this highland would be entirely above sea level except possibly for a narrow, deep channel along the demarcation line between "Lesser" and "Greater Antarctica".

In summary, the structure of "Lesser Antarctica" is not simple. In most places the ice rests directly on rock but there are large areas, the floating ice shelves, where it does not. The ice sheet is not a symmetrical snow dome, but apparently began to grow in several isolated areas which later coalesced, filling the intervening lowlands with ice. There is no broad depression in the rock floor between the Ross Sea and the Weddell Sea. Antarctica is one continent, although the area of the continent is not as large as a map of the ice sheet would suggest. Several mountainous areas at present connected with the mainland by ice would become islands were the ice to melt.

Acknowledgements

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THE PALAEOMAGNETISM OF SOME IGNEOUS ROCKS FROM ANTARCTICA

BY D. J. BLUNDELL*

[*MS. received 26 August 1960.*]

A century ago geologists first began to consider the possibility of large lateral shifts of the continents. Reconstructions of the ancient positions of the continents have been proposed at various times since to try to explain past climatic zones, faunal distributions, similar orogenic sequences and structural trends on adjacent continents, and many other detailed geological events. Prominent amongst the hypotheses is that generally known as the Continental Drift Hypothesis, developed independently by F. B. Taylor and A. Wegener fifty years ago and later modified by A. L. du Toit and others. In this hypothesis two primeval continents, Laurasia and Gondwanaland, are supposed to have formed at the north and south poles, to have broken up and possibly to have grown, and the pieces to have drifted to the positions of the present continents. The continents are moved around by forces of unknown origin and their interaction with each other and with the substratum gives rise to orogenesis. Due in large part to the lack of any known forces capable of producing these movements the hypothesis is nowadays less favoured than others requiring no drift. Recently, however, the study of palaeomagnetism has provided an independent line of evidence. From it the ancient latitudes and orientations of the continents can be worked out and relative displacements may possibly be revealed.

Palaeomagnetic studies of the continents that are supposed to be fragments of Gondwanaland, i.e. Africa, Antarctica, Australia, India and South America, were begun by various workers in order to test the hypothesis. In Antarctica some intrusions in the Theron Mountains, Shackleton Range and Whichaway Nunataks were sampled by P. J. Stephenson during the Commonwealth Trans-Antarctic Expedition, 1955–58, and an extensive collection was made in the Graham Land area. During the summer 1957–58 the Falkland Islands Dependencies Survey ships R.R.S. *Shackleton* and R.R.S. *John Biscoe* set down the author at more than a hundred localities, enabling a very wide sampling to be made, from the South Shetland Islands in the north to Marguerite Bay in the south. FIDS geologists have since made further collections from the more inaccessible places in Marguerite Bay, Duse Bay, Livingston Island and King George Island. Altogether over 600 oriented samples have been collected.

The directions of the remanent magnetism of most of these samples have now been measured using an astatic and a spinning magnetometer. Tests of the stability of the magnetism have been made by storage and in a number of

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cases by partial demagnetization in alternating fields. In this way evidence can be given that the direction of the remanent magnetism measured in the laboratory is the direction of the magnetic field prevailing when the rock first formed. Since all the rocks dealt with are igneous this means the time at which they cooled from a magma during extrusion or intrusion.

It is well known that the present earth's field varies from year to year, but when the effect of this secular variation is removed, or averaged out, then the earth's field is simply equivalent to that of a dipole located at the centre of the earth directed along its axis of rotation, and is known as the present dipole

Fig. 1. Pole positions (with ovals of 95 per cent confidence) from measurements on dolorite intrusions of (1) Theron Mountains,[1] (2) Ferrar Glacier,[2] and (3) Wright Glacier valley.[3]

field. In other words, over a thousand years or so, a compass needle in the Graham Land area would, on average, point towards true north and be inclined upwards at about 77° to the horizontal. This is also found to be the average direction of the remanent magnetism of late Tertiary volcanics and dykes from nine sites in the South Shetland Islands. The directions of magnetism of three lava flows of the mid-Tertiary James Ross Island volcanics are grouped exactly opposite to the present dipole field, and probably indicate that the polarity of the earth's field was reversed when the lavas were extruded. A fourth lava flow is magnetized along the present dipole field direction.

The major part of the Graham Land peninsula is made up of the Andean Intrusive Suite. This was sampled extensively, and from sixty-four samples taken from eleven localities it is clear that the field prevailing in the early Tertiary, when the suite was intruded, was the same as the present dipole field. The scatter of directions between the localities is of just the right order to be explained as due to secular variation of present-day magnitude. There have been no relative rotational movements from one locality to another since the beginning of the Tertiary. These results are taken to show that since the very beginning of the Tertiary in this part of the world the earth's magnetic

Fig. 2. Pole positions (with ovals of 95 per cent confidence) from measurements of Jurassic rocks from (1) South America,[4] (2) Africa,[5] (3) Antarctica,[1] (4) Australia[6] and (5) India.[7]

field has remained essentially constant. There have probably been reversals of polarity, but taking account of these the field prevailing is the same as the present dipole field. This can be interpreted to mean that there have been no major movements of Graham Land since the Andean Suite was intruded.

Jurassic lavas have been sampled from several localities in the Argentine Islands, King George Island and Lallemand Fjord but in every case no result of any value has been obtained. It is suspected that much, if not all, of the original magnetism of the lavas was destroyed when the Andean Suite was intruded. The samples of Jurassic dolerite intrusions in the Theron Mountains

region collected by Stephenson[1] have been very valuable. They are magnetized on average with azimuth 64° E. of N. inclined upwards at 68°, and the scatter about this value encourages the belief that the mean direction is significantly different from both the present field and the present dipole fields. Assuming the field was dipolar in the past, then the ancient pole position can be calculated, and is found to be in lat. 54° S., long. 136° W. (Fig. 1). Two results from Victoria Land of measurements on intrusive rocks of comparable age give pole positions at lat. 58° S., long. 142° W.,[2] and lat. 51° S., long. 132° W.[3] (Fig. 1), assuming a dipolar field. The excellent agreement shows that, over a distance of continental magnitude, the earth's field in Jurassic times had the same dipolar character that it has had since the Oligocene. Yet if pole positions similarly calculated for Jurassic rocks from all the Gondwanaland continents are plotted (Fig. 2) there is seen to be a wide scatter. If the earth's field in the Jurassic was dipolar this scatter can be explained if relative displacements of the continents are assumed to have occurred. If the pole positions are brought to one point the positions of the continents in the Jurassic may be reconstructed. In doing this it is not possible to discern the ancient longitudes of the continents, so an infinite variety of reconstructions could be drawn. The most sensible form of reconstruction would appear to be one in which minimum displacement of the continents is required, and such a reconstruction for the Jurassic puts the continents in positions quite similar to those that have been given in reconstructions of Gondwanaland by proponents of the Continental Drift Hypothesis.

Of the rocks older than the Jurassic to be found in the Falkland Islands Dependencies the only ones of palaeomagnetic value are the older intrusives of Marguerite Bay. Their age is not well known but is Lower Palaeozoic. Samples from two localities are magnetized 348° E. of N. in azimuth with 56° upward inclination. This might suggest that when the rocks were intruded Marguerite Bay lay in about lat. 40° S.

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DIVING IN ANTARCTIC WATERS

BY M. NEUSHUL*

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Introduction

The traditional methods of studying the marine biology of any coastline almost always involve the collection of plants and animals when the shore is exposed by the fluctuation of the tides. In the Antarctic, however, intertidal collecting is generally impossible due to the continuous abrasive action of floating ice, which scours this zone clean. Further difficulties are encountered in areas where fast ice extends out directly into the water, leaving no intertidal zone exposed. Thus our knowledge of the marine plants and animals of the Antarctic has been obtained largely through the use of the dredge. Skottsberg,[1] in 1906, provided the first indication that there was, below the action of the ice, a rich growth of large marine algae. Unfortunately the bulk of his collections were lost when the *Antarctic*, the ship of the ill-fated Swedish Antarctic Expedition, 1901–03, was crushed and sunk by pack ice.

This is an account of an attempt to find out if it was feasible to use diving equipment for making repeated dives in Antarctic regions in order to study the ecology and species composition of this reputedly rich area; also to find out if a selective collection of the little-known plants and animals characteristic of the Antarctic sublittoral could be made by hand.

These studies were aided by a contract between the United States Office of Naval Research and the Scripps Institution of Oceanography of the University of California. The trip was made possible by the generous invitation of the Argentine Navy, whose facilities and ships were used during the course of these investigations. Close co-operation, equipment and assistance was provided at all times.

The companionship of Lieutenant R. O. Dains, U.S.N. and Teniente de Corbeta Juan Carlos Carosella during the diving activities and during the strenuous and often unpleasant overland trips to diving localities was greatly appreciated. One cannot emphasize too greatly the necessity for complete confidence in one's diving companions under the unusual diving conditions to be met in Antarctic waters.

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Areas visited

Sailing from Ushuaia, Tierra del Fuego, on the Argentine icebreaker, *General San Martin*, on 1 January 1958, we crossed Drake Passage in good conditions and were left at "Teniente Camara", on Half Moon Island in the South Shetland Islands. It was here that a large part of the test diving was done. During the first few days we were confined to the huts by strong winds and snow that made diving both out of the question and hideous in prospect. With more pleasant weather we began to test various combinations and types of equipment. After the initial testing period lasting about one week, we began overland trips to various parts of the island where dives were made from the shore. During the latter part of January we were taken on the *Chiriguano* to temporary Argentine summer stations on King George Island. Dives were made also at Harmony Cove and Deception Island. On 4 February we boarded the *Bahia Aguierre* and visited Hope Bay, the Melchior Islands and the continental base "Almirante Brown" at Paradise Harbour. Dives were made in all of these localities.

During a total of 71 days spent in the Antarctic, thirty-three dives were made in water ranging in temperature from 1° C. (34° F.) to as low as −1·5° C. (29·5° F.). Although repeated short dives were made, the longest continuous period spent in the water was slightly over one hour. Dives were made to depths down to 20 m.

Diving equipment and techniques

The diving equipment included both "dry"- and "wet"-type exposure suits with full hood protection, gloves, mittens, boots, face plates, different types of fins, depth gauges and other standard diving equipment. In addition a small portable air compressor, compressed air tanks, and demand type regulators were taken. The Argentine Navy supplied heavy-duty constant-volume diving suits, compressed air tanks, and self-contained oxygen rebreathing units.

The short working time made it necessary to find the most efficient combination of equipment as quickly as possible so that observations and collections could be made. Thus certain articles of equipment were discarded after limited use, and no concerted efforts were made to assess the relative merits and demerits of each individual article of equipment thoroughly. Some, such as face plates and fins, depend upon the individual who is diving.

Protective clothing. Two types of "dry" suits were used, a regulation United States Navy "dry" suit with seals at waist, neck and wrists, and the Cousteau "Constant Volume" suit with seals at the neck and wrists. The United States Navy suit and undergarment combination is the same as that described and illustrated by Fain.[2] The Cousteau "Constant Volume" suit used is of heavier rubber. Both "dry" suits suffered from similar disadvantages, they were cumbersome to put on, and if a leak occurred in the water, it was difficult for the diver to re-adjust the suit himself. With both the "dry" suits, punctures and cuts on ice and stones were experienced during the course of working

Foam neoprene "wet" suit and diving apparatus used in Antarctic waters

Photograph by M. Neushul

(*Facing p.* 354)

dives. The "dry" suits also somewhat restricted the swimmer's arms and legs while in the water, slowing his speed; as activity generates warmth, this feature is important. For long periods in the water, however, where one is not able to swim vigorously, the "dry" suit with several layers of insulating underwear is superior to the "wet" suit.

Two types of foam-neoprene "wet" suits were used with great success, and ultimately all of the diving was done with this type. Both strip reinforced and non-reinforced suits were tried, of different thicknesses of neoprene ($\frac{3}{8}$ in. and $\frac{5}{16}$ in.); both provided protection, the thicker being the more comfortable. The suits were individually tailored, as the fit under these conditions was found to be very important. Short trousers were inferior to long ones that came high around the chest. Reinforced knee pads protected the suit against cuts from ice. Reinforcing under the arms was useful as one tends to use the arms a great deal in cold water, especially when free-diving from the surface. It was found that one could stay longer in the water if one swam continuously, possibly due to the generation of heat by such activity. Any leak in the suits results in immediate termination of a dive; the rapid entry of water into the suit being an extremely uncomfortable, if not painful, experience.

The "wet" suit had the advantage that it could be worn with relative comfort while travelling over-land to the diving location, or for long periods in a small boat. This type of diving suit can also be worn comfortably under other clothing such as a parka. "Wet" suits were worn for as long as six hours on several occasions.

The biggest problem with both the "dry" and "wet" type of protective clothing is keeping the head, hands and feet warm, so considerable attention was given to the choice of gloves, mittens, hoods, face-plates, boots and fins. The exposure of any part of the body to direct contact with the water must be avoided. Water entering a wet suit is initially cold, but is soon warmed by the body; as long as it does not circulate within the suit, allowing more water to enter, the diver is perfectly comfortable.

In order to remain submerged, full covering of the face is necessary. When a full face-plate is used with the breathing apparatus, the normal types of open face hood can be used. However, if the ordinary face-plate is used, an extension of the hood to cover the lower face is needed. (See photograph on p. 354, where the face-plate is shown pulled out of position.) A small hole in the hood over the mouth can be stretched and the snorkel, or demand valve mouthpiece, inserted. The face-plate fits against the skin and the hood fits over it. Either saliva or a small amount of water inside the face-plate was found to be adequate to prevent fogging. The full face hood was used, and worked well even when it was worn over the open-faced dry suit hood.

Protection for the hands used with the "dry" suits was provided either by rubber gloves with suitable woollen gloves underneath, or by mittens, made from foam neoprene, that could be used with either type of suit. The "wet" suit mittens were best when there was ample room inside them, any tightness that impeded circulation, even slightly, was found to be uncomfortable.

With both mittens and boots of the "wet" suit a long cuff was found to be desirable, as this prevented water circulation and heat loss. The long overlap of the leg or sleeve is far better than a tight encircling of the wrist or ankle.

The feet were very difficult to keep warm, mainly because the swimming fins were worn outside the "dry" or "wet" suit boots. To secure the fins, a certain degree of tightness is necessary; thus, even though the boot is loose, some constriction can be expected from the fin straps. The most comfortable boot and fin combination is shown in the photograph where the fin is "shoe-like" and its position on the foot is governed by uniform pressure around the foot, rather than a tight strap around the heel, or a tight fit around the ball of the foot.

Breathing apparatus. The underwater breathing apparatus employed was of two kinds: the usual compressed air tanks with air demand valves, and the Pirelli self-contained closed circuit type. No difficulties were encountered with either. As oxygen is a usual medical supply, it was easy to re-charge the oxygen cylinders of the closed-circuit apparatus.

Scientific apparatus. Among the scientific and other diving equipment used were depth gauges, compasses, an underwater movie camera, light meter, and a galvanometer and barrier-type photronic cell used for measuring the penetration of light into water. Also used regularly were more usual types of apparatus such as matt-surface plastic for underwater writing, collecting knives and bags. All of these things worked well under Antarctic conditions and no difficulties were noted that would not have occurred in warmer waters.

Safety precautions. Preoccupation with one's physical safety during any diving activities is a serious limiting factor in the amount of work that can be accomplished. Experience with the equipment to be used and familiarity with the techniques of systematic observation and collection are even more important under the unusual conditions present in the Antarctic. All diving was done in pairs, one diver carrying out the necessary work while the other stayed very near him, according to a pre-arranged plan. A deflated life jacket was worn with all combinations of diving equipment; it could be inflated by pulling a cord which opened a small carbon dioxide cylinder. In all of the dives made from the shore, an observer was posted with a shrill warning whistle in case Leopard Seals, or other large marine mammals, were seen. Only on two occasions was it necessary to leave the water for this reason. When dives were made from small boats, observers watched the surface bubbles closely.

No dives were made under solid ice, but on several occasions they were made in brash, or loose growlers, and around stranded icebergs. When diving around ice, it is necessary to exercise great care, since protective clothing can be damaged by the sharp edges of freshly broken pieces. The presence of ice on the surface may hamper swimming and can knock off a face-plate or catch on projecting equipment. Larger pieces, moving in the surge near shore, can severely bruise a swimmer, particularly when he is entering or leaving the water. Entering or leaving the water from the shore is much less hazardous if the swimmer refrains from walking on the bottom and keeps on top of the

ice as much as possible. Some types of ice are more dangerous than others; of these, clear "growler" ice seemed to be the sharpest when broken by surf action. If it was necessary to mount larger pieces of ice in order to reach shore, it was found advisable to keep off the hands and knees as much as possible and to find smooth hand-holds with which to pull oneself over the ice on one's stomach. In order to prevent them catching on the ice, the weights on the belt were kept at the side of the body, and the knife in the small of the back.

Collections and observations

The foam neoprene "wet" suit and snorkel was used for a great deal of the collecting and plants and animals were collected to a depth of 30 ft. in this way. Freedom from encumbrance made it possible to swim along the shore examining the bottom for favourable collecting areas, or unusual associations of organisms.

Collecting animals and plants underwater presented no special problems. The mittens used made it rather difficult to pick up small plants or animals, however, with the aid of a short knife, most small specimens could be dislodged and scooped into a small collecting bag. In deeper water, surface ice limited visibility and hampered collecting; in such cases, rocks were brought back to the surface and examined for smaller plants and animals. The extreme clarity of the water generally made collections and observations both pleasurable and easy. In some areas, near large active glaciers, more opaque waters were noted.

Observations of ice action on the sea floor, and its influence on the plants and animals, were made. Larger icebergs had the greatest effect on the sea floor where it was composed of mobile material; they were observed gouging hollows or trenches of considerable size.

Antarctic marine algal growth is rich. At depths in these waters below the influence of ice action, and within the range of light penetration, marine algae flourish and apparently do not have to contend with the low salinity which is said to deter algal growth on certain Arctic coasts.[5]

The use of the dredge by Skottsberg[1,3] and Gain[4] provided the first indication of the abundance of marine animals and plants bordering the Antarctic. However, the nature of the bottom in many areas was such that the dredge merely skipped over the surface of the rocks or became caught between them. Skottsberg[3] stated that the only reliable way of obtaining an accurate idea of the plants and animals growing in Antarctic waters is through the use of a bathysphere or by diving. This certainly seems to be true, for many plants were found growing only in areas not accessible to the dredge. The large size of some of the plants[6] also makes dredging difficult.

Incidental observations were made on the diving habits of penguins and the activities of fish and invertebrate animals. Molluscs such as the limpet, *Nacella polaris*, were ubiquitous and easily collected. Chitons were also found on the sides and beneath rocks. Fish, mostly *Notothenia corriceps*, were few but easily collected since they moved away only when touched or otherwise

disturbed. Even though these animals live under conditions of constant low temperatures, no sluggishness was noted in their activities. Penguins in the water were inquisitive, and in one case came near enough to be seen underwater. The extreme speed and manœuvrability of these birds underwater is striking when compared with their activities on land.

The observations and collections made during the course of the diving activities were of a preliminary and exploratory nature. It is hoped that, with the study of the specimens and data obtained, a more complete account can be given of the abundant life found in the Antarctic sublittoral, and that the experience gained will be valuable for future studies of marine biology.

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OIL AND GAS EXPLORATION IN NORTHERN CANADA

BY A. T. DAVIDSON*

[*MS. received 10 October 1960.*]

About 80 million acres on the mainland of the Northwest Territories and Yukon, and over 40 million acres on the Arctic islands, are under oil and gas exploration permit. Exploration permits were issued in the Arctic islands for the first time in June 1960, following promulgation in April of new *Canada Oil and Gas Regulations* for federal government lands. The issue of these permits extended the northern oil and gas search from the Alberta and British Columbia borders, in lat. 60° N., northward to the Arctic islands; in terms of land area this is one of the most widespread oil and gas searches in the world. The Arctic islands exploration also holds particular interest since it is the farthest north oil and gas exploration ever carried out.

The new *Canada Oil and Gas Regulations* attracted widespread attention in the industry because, for the first time in Canada, they require that companies holding oil and gas lands beyond the exploration stage, or companies producing from these lands, be incorporated in Canada (i.e. be Canadian companies) and make shares of their stock available on Canadian stock exchanges. These regulations are an expression of the government's concern that decisions on development of Canada's basic resources should not be made outside the country.

This vast area in the north is in a very pioneer stage of oil and gas exploration. The north has only one producing oil field, Norman Wells, discovered as long ago as 1920 and one of the first in western Canada. Widespread exploration has only been under way, however, in the past 3 years. In the summer of 1959 over 40 exploration crews, with 400 men, took part in the search. A significant discovery of oil and gas was made in the "Eagle Plain" in Yukon Territory. Over 20 "wildcat" wells were drilled during the winter of 1959–60, and a number of them had interesting oil and gas shows. A major natural gas discovery was made in the southern part of the Mackenzie Basin. In the summer of 1960, a larger programme was carried out in the Arctic islands and a number of crews were active there.

The sedimentary basins of the north are large. They are part of the great interior sedimentary basin of North America that stretches northward from the Gulf of Mexico, through much of the central United States and the Prairie Provinces of Canada, narrows like an hour-glass near Norman Wells, and then fans out into the Arctic islands. Oil and gas exploration has in general moved northward in this basin during the last half-century. The parts of it already

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ARCTIC OCEAN
ALASKA
ALERT
ELLESMERE ISLAND
SCALE OF MILES
100 0 100 200 300 400 500
LEGEND
Lands under Oil and Gas Exploration Permit 75,744,752 Acres
Lands under permit (Arctic Islands) 40,603,338 Acres
Existing roads
Roads under construction
GREENLAND
70°
BANKS ISLAND
RESOLUTE
BAFFIN BAY
AKLAVIK
INUVIK
TUKTOYAKTUK
EAGLE PLAIN
DISCOVERY
DAWSON
YUKON TERRITORY
KENO HILL
VICTORIA ISLAND
CAMBRIDGE BAY
COPPERMINE
NORMAN WELLS FIELD
NORTHWEST TERRITORIES
DAVIS STRAIT
BAFFIN ISLAND
FROBISHER BAY
WHITEHORSE
ROSS R
YELLOWKNIFE
BAKER LAKE
CORAL HARBOUR
RANKIN INLET
SUGLUK
NAY RIVER
FORT SMITH
FORT VERMILION
BRITISH COLUMBIA
ALBERTA
HUDSON BAY
FORT CHIMO
NEWFOUNDLAND
CHURCHILL
COAST OF LABRADOR
GREAT WHALE

explored and developed, from Texas to Alberta, are one of the great oil and gas producing areas of the world. The Sverdrup Basin, the extension of this sedimentary basin, north of lat. 70° N., is roughly similar in basic geology to parts of it farther south. In fact, there are no sedimentary basins in the world of this size that do not contain substantial oil and gas resources, although, of course, some are more prolific than others.

It is a common practice to apply rule of thumb estimating techniques to virgin sedimentary basins to get a rough idea of their oil and gas potential. These rules of thumb are based on volumes of sediments, and known oil and gas reserves per volume, in explored similar sedimentary basins. When these are applied to the north, estimates run somewhere between 30 and 100 billion barrels of oil, and very large volumes of gas. These figures are so large as to be difficult to grasp. They do suggest that oil and gas in the north may be a very substantial resource—perhaps equal in value to the ultimate hard rock mineral potential. At $2.00 per barrel, the possible value is up to $200,000,000,000. In brief, one does not have to be an optimist to conclude one may be dealing with a major resource.

The Canadian government, vitally interested in promoting development of Canada's virtually unoccupied northern areas, is keenly interested in the development possibilities of northern oil.

It appears that northern oil and gas is the only northern resource with the early development potential to "open up" many areas of the north on a large scale over the next couple of decades. The development of hard rock minerals will be important but it will probably be slower and more cautious. Large-scale exploration for, and development of, northern oil and gas could result in the expenditure of many hundreds of millions and even billions of dollars in the north. Large expenditures on northern town sites, housing, transportation and communication facilities would be required and assured. Progress which now can be accomplished only over long periods, with relatively small public expenditures, would be forced ahead by pressing requirements of industry for new town sites, pipelines, roads, airfields, harbours, and telecommunications. Oil development elsewhere in the world has brought the most aggressive and advanced technology, backed by large sums of capital, to bear on local development problems. It has been a powerful catalyst in the development of underdeveloped areas.

It is easy to be carried away by the bright possibilities. There are, however, many problems and unknowns. There is now, and may well be for decades ahead, a world surplus of oil in spite of soaring world markets. Oil exploration techniques have been developed to the point where, world wide, more oil is being found than can be marketed. There is a restricted domestic market in Canada for large volumes of new oil. Western prairie crudes now discovered, and being discovered, can supply much of Canada's domestic needs for many years. In brief, the market outlook for northern oil and gas is difficult for a number of years ahead.

Oil and gas exploration in Yukon and Northwest Territories, including the Arctic islands.

Yet companies are taking out large areas of oil lands for exploration. There are a number of reasons for this. Broadly speaking, the physical problems of oil operations in the north have now been solved, although the costs of some operations may be high. The long-term markets justify a start at northern oil exploration with a view to production some years away. From the viewpoint of their world market position most large companies dare not be left out of large basins when others are in. With firmer nationalistic policies, the costs of production in some of the more prolific foreign areas continues to rise as governments take a bigger slice of the profit, and Canada is, politically, a particularly stable area in which to invest.

It is within this general framework, and in consideration of a number of other factors which there is no space to discuss here, that the Department of Northern Affairs and National Resources faces the problem of devising government policy for the development of this resource.

The Department's policy rests on two very general bases—first, to encourage early exploration and proving-up of the resource, and second, to protect the public interest in it, for it is all publicly owned.

It has been evident for some time that if there is to be an economic market for northern oil (and perhaps gas) in the next, say, fifteen years, it must be an offshore market or a world market—not a protected interior domestic market. This possible market includes the west coast of the United States, Japan, Europe, as well as Montreal. In these markets it will have to compete with low-cost foreign oil and accordingly must be produced more cheaply than high-cost western Canadian crude or United States crude which cannot so compete. Since northern exploration and development costs, because of the facts of northern geography, will be somewhat higher, this appears a difficult objective, but the Department is confident lower cost oil can be produced.

The high cost of United States crude and Canadian crude is basically due to multiple ownership of oil lands over single pools, permitted or even required drilling by each owner even though wells may be marginal, resulting in local overproduction and, in turn, pro-rationing of each well to market demand. The result is inefficient production, too many wells, most producing at only a fraction of their capacity. The price must be high to make marginal wells with low productivity pay at all. In most foreign areas, because of bold land-holding patterns and unit operation of pools, wells are drilled only to meet market demand, usually produce near their full engineering potential, and there is no pro-rationing.

The Department is attempting to lay the groundwork for lower cost oil in the north by a policy of bolder land patterns, early unitization (unit operation) of fields, wide well-spacing and avoidance of pro-rationing, and in this way to establish a basis of production more similar to that in the Middle East or South America. This policy of low-cost oil through partnership with industry has required considerable new thinking in North American oil law. It appears to form the only basis for early northern oil development, but only the years ahead will determine whether this objective can be achieved. If it

can be demonstrated that northern oil can be produced competitively, much more active exploration will be encouraged. Much, of course, will depend on whether or not prolific fields are discovered.

Of course one easy way to obtain early northern oil development would be to dispose of it to large corporations at extremely lenient terms. But the other basic policy objective is to protect the public interest in the resource. The two basic objectives, encouragement of development and protection of the public interest, must be continually balanced.

The Department's policy requires that permits be vigorously explored; companies cannot sit on the land. Basic expenditure obligations on permits now held will require over $400,000,000 to be spent on exploration in the next decade, if these permits are retained. Leases on productive or potentially productive lands are granted for a period of 21 years and a royalty of 12½ per cent must be paid to the Crown on the production of all oil and gas. One-half the permit area reverts to the Crown when leases are granted. In this way the Crown will retain a large part of the oil and gas resources to meet its policy objectives at that time, whether these objectives be more revenue, more exploration and development, Canadian participation, or a number of others. In addition, the Crown will obtain through general taxes nearly half the profits from any production on all lands. The oil law assures the Crown substantial returns in revenue and maintains a strong position for it in the disposition of the resource. The Crown, both as landlord and regulator of production, retains the dominant hand in its partnership with private industry. The resource is far from being given away.

However, the balance between encouragement of investment and protection of the public interest in the narrow sense must be constantly reviewed and adjusted in the light of developments and pressures. It is the Department's objective to have large parts of the northern basins evaluated by exploration within the next ten to fifteen years, but this can be achieved only through highly enlightened policy. Such policy can both protect the public interest and serve the broad national interest.

Those interested in the north often ask what the specific implication of such development will be to the north. It is difficult and hazardous to make specific predictions. However, it is clear that when large-scale production is under way, government revenues could run in the order of $100,000,000 annually, and expenditures by oil companies would reach several hundreds of millions. Many of the technical problems of the north would be economically solved because the best technical knowledge of industry and government would be brought to bear on them. While large fields were being developed, hundreds to a few thousands of men would be employed. About 5,000 men are now employed in development of French oil fields in the Sahara. Oil fields under production would be largely automated and manpower use would be small. The direct employment in the oil industry would never be very large, although there would certainly be more than enough employment to use all the northern natives who could be technically trained for such work. It is not too early to begin training these people with oil industry needs in mind. Six Eskimos are

now employed on a northern drilling rig. This employment could be multiplied very many times. Although service centre towns will not be large, new pipe lines would be built, also oil- and gas-cleaning plants, tank farms, equipment servicing warehouses, and so on. Development of the resource, barring tremendous unforeseen technological changes which radically affect the value of oil, would go on for a period of forty to sixty years at least.

To those interested in the development of the far north, the stakes in northern oil and gas resources are high. These undiscovered assets could be the means of opening up the north. Oil and gas development should focus interest on the development of adjacent hard rock mineral resources. In certain areas the exploration of hard rock and sedimentary minerals can complement one another.

If the hopes raised by northern geology are realized and good discoveries are made, if progressive policies can be devised to produce northern oil competitively, this resource will forge the key to development of hundreds of thousands of square miles of the Canadian north within the next fifteen years.

LOGISTIC PROBLEMS IN THE CANADIAN ARCTIC*

BY T. A. HARWOOD†

[*MS. received 22 August 1960.*]

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Introduction

In 1946 the United States Weather Bureau and the Canadian Meteorological Service installed the first of the Joint Arctic Weather Stations at Resolute Bay. The network of satellite stations was extended into the Arctic archipelago in the following years on roughly a 275-mile spacing to Mould Bay, Isachsen, Eureka and Alert.

This new method of development and exploration was dependent entirely on suitable icebreakers and aircraft. Fortunately, as a secondary result of the Second World War, icebreakers of considerable power and size were available and could be used in the initial supply and re-supply of the main bases. Similarly the C54 (DC4) also became available for use in setting up the satellite stations.

It has been the existence of these Joint Arctic Weather Stations, together with their runways and other facilities, that has made it possible to carry out the more complex explorations of recent times, and to provide air weather services to the commercial airlines in the area. Furthermore, it is the lessons successfully learned and applied in the setting up and re-supply of these stations between 1946 and 1952 that allowed the development of the newer and larger centres like Foxe, Thule, Cambridge Bay, Cape Parry, and many others, which have vastly eased the problems of the modern developer and of geological exploration companies.

For any operation in the Arctic there is always a fairly complex logistic problem to be solved. Obviously the nature and complexity of the problem depends on the size of the operation, but some general ground rules can be laid down. Many of these rules have been developed over the years and have been incorporated into the standard operating procedures of the United States Navy for their own operations in the Arctic and Antarctic.

In all that follows, it would be wise to bear in mind that to drill a well in northern Alberta 750 tons and more are required. This is the problem that the logistics manager working on an oil exploration project in the Arctic islands has to face.

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† Defence Research Board of Canada.

Transport

In all operations north of the mainland, it is the successful sea operation which is the crux of the logistic problem. Such an operation depends entirely upon the proper organization of ships, icebreakers, and unloading facilities; the latter may be non-existent.

The organization of convoys with icebreaker escorts is not a difficult matter and has been successfully undertaken by the Soviets, Americans, and latterly Canadians. Successful maritime convoy organization is based on three principles. These are:

(*a*) Ship positioning in the convoy.
(*b*) Proper communication between ships and escorts using whistle, flag, and ship-to-ship radios.
(*c*) Ice reconnaissance.

The optimum number of ships to be escorted by a single large icebreaker is no more than ten ships, and preferably less. These ships are arranged in sequence of power, the assumption being, and borne out in fact, that the most powerful is the most controllable, and thus the least controllable must be "tail-end Charlie". Necessarily the control of the movement of these ships is often critical, and it is essential for each ship in line continually to be aware of what the others' intentions are by means of a whistle code and intership radio.

Such convoy operations are normally conducted in the various Arctic areas as follows:

Labrador Coast—late June to late October.
Foxe Basin—end of August to end of September.
East Baffin—end of July to end of September.
South Greenland—mid May to mid October.
High Arctic—mid August to mid September.

By the end of October, most ships are once more back in their home ports and, as far as they are concerned, the operation is finished for another year, though the last ship and the last aircraft do not leave the area until the end of November. Meanwhile the planning staffs, and all convoy commanders, are busy preparing a summary of the year's efforts, taking the opportunity to assess lessons learned and to make appropriate recommendations for the future. Before the ink on the final report is quite dry, it is January again and once more time to meet with the shipper services for cargo details for the forthcoming year. Thus, Arctic operations are a year-round planning and operating function. This will be discussed in greater detail below.

Ice reconnaissance, both long range and short range, is also essential to good convoy discipline and operations. It is used to indicate (*a*) long-range ice conditions—the most feasible routes to be taken in the next 24 hours, and (*b*) short-range ice conditions—the tactical route in the next 4 hours. The first is undertaken by long-range aircraft and the latter by helicopters. Recently, closed circuit T.V. has been used in the latter. The methods for

operating in ice are well dealt with in the *U.S. Navy publication HO* 274 and in the new *Canadian Arctic Pilot*, Vol. 1.

Assuming the convoy, or in certain cases the single ship, approaches the beach successfully, the problem then is the unloading and this can have many pitfalls, not the least being the miscalculation of the period of unloading due to poor cargo handling, scattered ice in the harbours, and insufficient landing craft. However, there are a few simple but important rules for any seaborne operation which has to unload over an open beach; these must be followed if success is to be achieved. These are that:

(*a*) The operation must take place at a period when ice conditions are favourable, but not so far advanced in the season as to inhibit the efficient sorting and redistribution of cargo.

(*b*) The ship should be loaded in such a way that first requirements come ashore first.

(*c*) The beach areas must allow, under the worst conditions, stowage of all the cargo involved, or, at the best, that percentage calculated to remain on the beach when the landing operation and the beach removal operation are running hand in hand.

(*d*) The number of landing craft, cranes, bulldozers, stone boats and trucks necessary for beach operations must be related properly to the ship's speed of discharge.

(*e*) The cargo beach areas must be properly marked.

(*f*) Adequate food, shelter and sleeping quarters must be provided on the beach for the beach crews.

(*g*) Fuel oil, and if possible gasoline, should be off-loaded in bulk and run into drums on the beach.

Of all these simple and fairly obvious precautions the one most neglected in the past, and which has caused the most trouble, is that regarding adequate beach areas. A thousand tons of cargo covers approximately 20,000 sq. ft. and additional space must be left for beach handling. Once the beach parties become cramped for space, disorganization immediately sets in.

From the above, it also becomes apparent that any ship must have heavy booms, 25 tons minimum capacity, with a major lift of 50 tons to handle equipment.

The pre-loading of small items together on platforms, or "pallets", also deserves some mention since it affects both the ship and the aircraft if an onward movement has to take place, and this is highly likely in any probable oil exploration programme in the Arctic islands. The size and volume of the items thus pre-loaded of course depends on a number of factors, the major considerations if an airlift is involved being (*a*) the size of the aircraft door, (*b*) the floor loading, and (*c*) the fork lifts available. These, if DEW Line experience is any guide, particularly in the Eastern Sector, are nearly always disregarded in the initial planning of such an airlift. Naturally the larger the pallet the more efficient the operation, provided of course the pallet can be moved once on board the aircraft, another detail often forgotten. The loading on to pallets should be carried out prior to loading the ship.

It has so far been assumed that the sea operation must be combined with an air operation for oil or seismic exploration in high latitudes. This may not

necessarily be the case; in fact heavy tractor-train operations are probably quite feasible over reasonable distances. Here again are some simple rules which should be kept in mind with regard to the efficiency and safety of a tractor train. These are:

(*a*) The break-even point between large aircraft (DC4 and up) using ice runways and tractor trains should be determined by an exploration company's logistics manager well before any decision is made. At distances over 150 miles there is every probability that in the Arctic islands the aircraft may prove the cheaper, particularly in mid-winter.

(*b*) Ice thickness, and therefore the strength of the ice in the channels between the islands, is at its maximum in early spring but once insolation exceeds radiation the strength of sea ice quickly diminishes. Tidal currents also erode the undersurface of sea ice rapidly. Thus, if at all possible, the route should be reconnoitred in the summer for such danger points as tide rips and overfalls.

(*c*) The tide crack always constitutes a danger and an obstacle, particularly in the spring, and any approach from the shore to the beach must be reconnoitred before being made. This should also be borne in mind when ice runways are used.

If, however, it appears that an aircraft operation is both essential and economical, then one must also assume, certainly in the preparatory stages of an exploration programme, that the landings will be made on an ice runway. Again one can give a few simple rules which if followed will provide maximum safety and economy in the operation of such a runway and thus the airlift. These are that:

(1) The behaviour of sea ice and fresh-water ice when loaded differ radically, and different bearing strengths must be assumed. Tables of ice strength are given in *US Army SIPRE Report* No. 36, and should always be consulted.

(2) For any kind of ice over shallow water there are differing critical speeds for taxi-ing. If an aircraft taxis at these critical speeds the ice will inevitably fail, irrespective of thickness and strength.

(3) Runway discipline must be maintained. De-icer and hydraulic fluid and fuel oils are fatal to an ice runway at the most critical period, that is, in the spring.

(4) Even should apparent failure of the ice take place under the undercarriage, final failure is unlikely to take place and the aircraft can be safely moved.

While a great deal of attention is usually paid by the operator to the adequacy of the ice strength, little is paid to taxi-ing speeds. In shallow water the critical velocity depends mainly on the water depth, and to some extent on the thickness of the ice. In the case of an aircraft, the major concern is with taxi-ing, and this usually occurs at or below 18 to 20 mph. Resonance waves generated at these speeds and below will cause aircraft to break through ice where all previous experience has indicated complete safety.

Table 1

Water depth (ft.)	4	6	8	10	15	20	30
Critical velocity (mph)	9	11	12	14	17	19	22

Table 1 gives the relationship of the critical velocity of moving loads on an ice sheet and over shallow waters of a given depth. To complicate matters,

however, in deep water this critical velocity depends on ice thickness. Table 2 shows this.

It can be seen that in the case of deep water and fairly thick ice, critical velocities are fairly high, and it is quite easy to taxi below these speeds.

Extensive operations on ice with heavy aircraft should therefore not be undertaken without a careful ice survey by properly trained personnel, and in the case of very heavy aircraft, additional, though quite simple, mechanical tests to determine ice strength are necessary.

Table 2

Ice thickness (ft.)	Critical velocity (mph)	Minimum depth of water (ft.)
0·5	19	40
1	23	60
2	31	100
3	37	140
4	41	180
6	48	290
8	53	410

Aircraft operations on the whole are very much the same as further south except for pre-heating engines. It has been the experience of both the USAF and the RCAF that in mid-winter a minimum safe ratio of Herman Nelson type heaters per engine at any fixed overnight base should not be less than 5/4 or 5 per four-engine aircraft.

Adequate overnight accommodation should also be provided at any runway shelter since camp sites normally are one or more miles from a runway, and this shelter should also have communications air-to-ground, and with the main camp.

Planning

The above factors suggest that operating in high latitudes must require a relatively higher support and logistic effort than further south. The question is how much more. A good answer has been obtained from the RCAF and the Canadian Geodetic Survey experience on the shoran survey operations carried out between 1946 and 1957. It was found that:

(*a*) in the south, or in habitable areas, 4 tons per man/year were required;
(*b*) in the north, but below the treeline, 8 tons per man/year were required;
(*c*) above the treeline to the Arctic coast, northern Quebec, and southern Baffin Island 12 tons per man/year were required;
(*d*) in high latitudes and the Arctic islands 16 tons per man/year were required.

These figures do not include aircraft fuels or aircraft at the main stations when an airlift is involved. It is assumed that these will be sealifted with an additional cost of no more than 6 cents per lb. over the continental price. In confirmation of the last figure, the supply and maintenance of the Joint Arctic Weather Stations (satellites) require an airlift of about 19 tons per man/year. The Russians claim their floating stations need approximately 16 to 19 tons per man/year, and the Defence Research Board Operation

"Hazen" in northern Ellesmere Island required about 14 tons per man/year. It should again be emphasized that these figures do not include aircraft fuels, or any more exotic piece of heavy equipment than a TD-9 type tractor to maintain the runways; they do include such items as building material, stoves, and power plants.

With much of what has already been related, it is now possible to plan for such an operation, but since the sealift is a yearly event much of the planning must be done far in advance. Experience has shown that such planning should follow somewhat this sequence:

(1) High-level planning conference for general details—housing, personnel, scale of programme, etc. D − 12 months.

(2) Staff planning of weights and volumes from port to beach and on to site, together with fuels required for flying from the main base to exploration site. D − 11 months.

(3) Discussion of administrative details with government agencies, such as icebreaker escort, licences, etc., site location of airstrip. D − 11 to D − 10 months.

(4) Arrangement of charter for ships and aircraft and planning for the airlift. D − 10 months.

(5) Visit to the area and completion of arrangements for storage at sites. D − 10 months.

(6) Ordering and purchasing and completion of arrangements for storage, arrangements for stevedoring in a southern port and on the northern beach site. Continuous from D − 9 to D − 2 months.

(7) Final planning conference at organizational headquarters, readjustment of volumes, weights, fuel loads, charters, etc., and priorities for beaching and unloading. Details for icebreaker escort. Final details for onward lift (spring or fall depending on conditions). D − 2 months.

(8) Final conference with stevedores and shipowners. D − 1 month.

(9) Combat loading. D − ½ month.

(10) Sail ship, arrive site. D Day ± 10 days.

(11) Unload and rearrange material for onward air shipment in the spring or autumn. D Day + 2 weeks.

(D Day will probably be in late August.)

Transfer of material from the beach to a runway should in all probability take a further two weeks. This may be phased in with an autumn airlift if one is available, or if a runway can be constructed at the exploration site before the autumn. The length of an airlift will depend on the size of aircraft available, the number of crews available, and the speed of loading. The minimum period with 24-hour flying in full daylight will be approximately two weeks per 350 tons on a 250-mile run with three side-door loading aircraft of the C54 type. Ramp aircraft would reduce this to about 8 days, and aircraft of the C130 and C124 types will further reduce the time, providing loading crews can handle the cargo. With aircraft of this size, ground handling now becomes critical.

At least 12 to 18 months must be allowed by a large exploration party for the logistics phase in any plan for an exploration programme involving ships and aircraft in the Arctic archipelago. Costs therefore will be high, the least of which will be the ship charter.

Conclusion

From all the above it is clear that extremely careful preplanning and organization is necessary. Furthermore, in the Arctic, high morale is an essential; poor organization will inevitably lower morale with resulting confusion and possible breakdown of the programme. Strangely enough the time for preparation for an Arctic operation has not been materially reduced since Frobisher's or Sir John Franklin's day.

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TRANSPORT, EQUIPMENT AND STORES USED DURING OPERATION "HAZEN", 1957–59*

BY G. HATTERSLEY-SMITH† AND J. R. LOTZ‡

[*MS. received 20 July 1960.*]

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Introduction

Operation "Hazen" was an IGY expedition, organized by the Canadian Defence Research Board to carry out scientific studies in the Lake Hazen area of northern Ellesmere Island, from April 1957 to August 1959.[1] From April to August 1957, a party of six carried out glaciological, glacial-meteorological, seismic, and survey studies on Gilman Glacier, and two geologists worked out from Hazen Camp, the main station on Lake Hazen. From August 1957 to April 1958, a party of four meteorologists wintered at the base camp. The third phase, from April to August 1958, involved a continuation of the 1957 studies on Gilman Glacier, an extension of these studies to the ice cap to the north of Lake Hazen, and a co-ordinated study of the Lake Hazen basin and of other parts of northern Ellesmere Island. The latter included meteorological, geological, limnological, geomorphological, botanical, zoological and archaeological work by twelve members of the expedition stationed at the base camp. In the summer of 1959, a limited programme of glaciological, meteorological and botanical research was conducted by a small party on Gilman Glacier. During the spring and autumn re-supply operations, the expedition received support and co-operation from the Royal Canadian Air Force, the United States Coast Guard, the United States Navy, the United States Air Force, and (for a week in 1958) from a "Supercub" aircraft flown by Dr Terris Moore[2] of Waterville, Maine.

Operation "Hazen" was primarily an airborne expedition; choice of housing, vehicles, stores and equipment was therefore governed to a great extent by weight considerations. Thus the huts at Hazen Camp were wooden-framed and canvas-covered; food was mainly dehydrated or chosen for its value in relation to weight; and transport relied on light vehicles, dog sledges, and, in the summer, on small boats on Lake Hazen and pack-dogs. By contrast with the larger IGY expeditions the provisions made for Operation "Hazen" were somewhat austere, particularly during the winter months, but there was

* Published by permission of the Chairman, Defence Research Board of Canada.

† Geophysics Section, Defence Research Board.
‡ Industrial Division, Department of Northern Affairs and National Resources.

certainly no hardship involved. The food stores had the great advantage that they could be relied on to keep for an indefinite period, and the transport required very little maintenance. At the same time members of the expedition received a good balanced diet, and it is doubtful whether light vehicles and dog teams could have been bettered for transport over a very varied terrain of snow, ice and bare ground on journeys no longer than 200 miles.

Temperatures ranged from −68° F. (−55° C.) at Hazen Camp in the winter to +65° F. (18° C.) in the sheltered valleys during the summer. The temperature on the glaciers in the spring and summer ranged from −30° F. (−35° C.) to +45° F. (7° C.). At Hazen Camp, winds tended to be light and storms were infrequent. Even on the glacier during the 1957–58 summer winds seldom exceeded 10 mph, and only one blizzard was experienced during the time the glacier camp was occupied.

Transport

Tractors. A heavy tractor was needed only in the initial stages of Operation "Hazen". A TD-9 tractor and a bulldozer blade and winch, weighing a total of 18,000 lb., were flown in on the first two C-119 aircraft flights to the lake in April 1957. This tractor was used to clear a strip for subsequent landings on Lake Hazen, and to haul supplies and a "Northland" sledge from the airstrip on the lake to the main camp. A J-5 "Bombardier" snowmobile was used for over-snow and over-land travel, and was extremely useful in the early stages of the expedition for putting in caches, and for hauling the "Northland" sledge; it was never used on the glacier.

Motor toboggans. Two "Eliason" motor toboggans were used on the glaciers during the summers of 1958 and 1959.[3] Although these toboggans have been used for survey work in northern Canada for a number of years, Operation "Hazen" was the first expedition to use them in the Arctic islands. At least three subsequent expeditions have employed them.

The machine weighs only 460 lb., and so can be easily lifted into aircraft; in 1958 two of these motor toboggans were flown by DC-3 ("Dakota") aircraft from Hazen Camp to Gilman Glacier. Four men can pick up and carry the machine out of any difficult places, or it can even be hauled by one man.

Speed control is relatively simple, and depends on a mechanical tension between the throttle adjustment on the engine, and a lever on the steering column. A driver needs little practice to get the feel of this control, and to adjust it for the various running speeds. If the lever is pulled back too suddenly—either through accident or inexperience—the machine can easily run away. The wire connecting the steering column lever to the throttle is subject to much strain, and snaps at times; a new wire, however, is easily fitted.

It was found, in practice, that two "Eliasons" were needed on the Gilman Glacier; if one broke down, or ran out of fuel, the other could be sent to haul it in. In this way at least one "Eliason" could be relied on, even if the other served solely as a source of spares. Suggested minimum requirements for

spare parts for two vehicles are: 2 drive belts, 2 throttle control cables, complete clutch assembly, 2 exhaust valves, 2 intake valves, 6 spark plugs, 2 back axles, 2 front axles, complete spare track, varied assortment of track and chain links. It is an advantage to fit a casing over the clutch assembly to prevent snow from clogging the drive belt. The simple construction of both the frame and the engine of the "Eliason" means that elementary servicing, or complete replacement of parts, will keep the machine going. No special mechanical knowledge is needed to carry out servicing.

The toboggan proved to be a thoroughly reliable, sturdy and efficient machine, admirably suited to the conditions encountered. It was used as a "runabout" for seismic and levelling traverses, and for visiting glaciological stations; it would haul up to 1500 lb. on a "Nansen" sledge. Its performance was good on all types of snow surface, from hard wind pack to deep, soft snow. A good, wind-packed snow surface offered the best "bite" for the track, and it was possible to reach maximum speeds of about 20 mph on this type of surface. In soft snow, the tracks would sometimes turn without moving the machine; on these occasions it was necessary to keep the engine running, and to lift the rear end of the machine on to a firmer surface. The machine is very stable, and rides well over skavler, but it is necessary to drive slowly in conditions of whiteout or fog. Bare ice should be avoided, for on an ice surface the machine is subjected even at slow speed to excessive strain which may damage the frame, the tracks or the axle. Thus, during the ablation season the machine can only be used above the firn line. In August 1958, a motor toboggan was lashed on a Greenland komatik and brought back to the Gilman Glacier camp by dog team over several miles of bare ice; this was much preferable to any attempt to drive the toboggan over the unsuitable surface. The machine can be run on a thin layer of snow over ice, but under these conditions the track links and lugs come in for heavy wear.

In crevassed areas it is possible to operate the toboggan without a driver sitting on the vehicle. If a line is attached to the throttle, the machine can be driven by a man walking or ski-joring at the rear, so that the risk of falling into a crevasse is greatly reduced.

Dogs. During the summer of 1957, two teams, each of ten sledge dogs, were obtained from Thule (Kanaq), Greenland, through the courtesy of the Danish authorities; one team belonged to the pastor, and the other to a school teacher there. The dogs were driven down to Thule Air Base for airlift in the spring, and returned to Kanaq by icebreaker in early August. Half a team was kept at base camp, for spring sledging, and one and a half teams were used for sledging on the glacier. The same two teams, and an additional one, were used again during the summer of 1958.

The expedition was very fortunate in its selection of dogs, which came well trained and in excellent condition. They were fed on "Nutrican", a specially prepared sledge ration packed in tins, each containing sixty individually wrapped 1 lb. blocks. At first the dogs were suspicious of this new food, but quickly came to like it. Each dog was fed 1 lb. per day and occasionally 2 lb. The dogs stayed exceptionally healthy during the summer, and the only loss

during the two field seasons was one dog with a wounded and gangrenous paw, which had to be destroyed. In the first year one dog was rescued from a depth of 97 ft. in a crevasse; he sustained only an injured front leg and was able to return for the 1958 summer. Sixteen puppies were born to the bitches of the expedition in the course of two summers, and these were returned to the owners of the dogs at Kanaq.

The dogs were usually driven in the "Thule", or true fan, hitch to which they were accustomed. This is certainly the best method of driving on the generally hard snow of the glaciers. However, in very soft snow, 1 to 2 ft. deep in the river valleys and fiords, the "Nome", or centre-trace, hitch was used, and the dogs quickly adapted themselves. Sealskin traces with spring clips and ivory toggles were used with the fan hitch and the traces were very rarely chewed, for the dogs were well fed. Traces made of sealskin are preferred to those made of nylon or hemp, as they are much easier to untangle. Most of the dogs came with sealskin and canvas webbing harnesses, which were in poor condition, and had to be replaced by dog harnesses of nylon webbing, made in the field in 1957 and obtained commercially in 1958. Belly bands were fitted under the harness as protection against a crevasse fall. Chains were used to tether the dogs in groups of 3 to 5 to "ice bridges"* when not working. It was common for the driver and one companion to ride the sledge, which might be loaded with 600 to 700 lb. of trail equipment, food and instruments for a 2 to 3 week glaciological or survey traverse, on which the party would be completely self-contained. There were certainly no inhibitions about riding sledges, for the dogs were not overworked; the two members of one sledge party, which made two traverses on the ice cap totalling about 200 miles, only walked 5 to 10 miles of this distance in an area where the snow was unusually soft. The dogs were driven from the sledge.

A geological party used pack-dogs on a journey of about 200 miles from Hazen Camp to Alert and back in 1958, and other shorter journeys with pack-dogs were made. During the evacuation of the glacier camp in August in both years, dog packs were used to carry some of the equipment, and personal effects. Some excellent Norwegian dog packs were available, but adequate packs were also made from heavy provision bags. One difficulty with both types of pack is that they tend to slip forward and hang around the dogs' necks. This problem can be solved by fitting the packs to the dogs, and making sure that each dog always has his correct pack, properly adjusted, before setting out. Gradually the dogs became accustomed to packing for which they are not used in the Thule area. It appeared that loads for the stronger and larger dogs should not exceed 20 lb.

"*Nansen*" *sledges.* "Nansen" sledges were made up to the specifications of the Norwegian–British–Swedish Antarctic Expedition.[4] The sledges performed very well on the snow and ice surfaces encountered on the glaciers. The runners of "Tufnol" bakelite slide much more easily than steel in temperatures below 15° F. (−9° C.), and show little tendency towards icing in higher temperatures. The "Tufnol" is very hard-wearing. It was found that

* Recessed cleats chipped in the ice.

two "Eliason" toboggans, each drawing a "Nansen" sledge, could handle the camping gear, food, and scientific equipment of a seismic team of four men for a week. Serious damage was only sustained on one occasion; at the end of the 1957 field season, two longitudinals and the tip of one runner on one sledge were smashed during a difficult journey with a heavy load over the melt streams of Gilman Glacier. Each part of the "Nansen" sledge can of course be easily replaced, and the assembly and repair of "Nansen" sledges took up very little time. Spare runners, longitudinals, bridges, slats and an abundance of twine and rawhide were needed for repairs.

During 1957, rope brakes were used; these hook under both runners and on steep descents were looped round the bows with a quick-release toggle. In 1958, a spade foot-brake, mounted between the runners at the rear, was used in conjunction with a rope brake at the bows. The front brake was connected by a spring to the cross-piece of the handlebars. On steep slopes the rear brake usually checked the dogs sufficiently to allow the sledge to be stopped and the rope brake was seldom needed, but it provided an additional safeguard.

Greenland komatiks. Two of these were bought from the Eskimos at Kanaq. Although rather heavy, they proved satisfactory over every type of surface encountered, from deep snow to bare ice. They withstood very rough usage for three summers. Loops of heavy rope were thrown round the front of the runners for braking.

Magnesium cargo-carrying toboggans. The expedition used Canadian Army man-hauling sledges of 100 lb. and 200 lb. capacity, mainly for moving light equipment and stores for short distances in the camp area. The 100 lb. sledge consists of a sheet of magnesium with upturned end, while the 200 lb. is boat-shaped in construction. They are unsuitable for use with dog teams, but are useful for carrying a light load behind an "Eliason" toboggan. The friction of these toboggans on snow is high, and compares unfavourably with the bakelite running surfaces of the "Nansen" sledges.

"*Northland*" *sledge.* This 2 ton sledge is mounted on four skis with spring suspension; its dimensions are 14 ft. × 8 ft. × 2½ ft. and its weight 1,800 lb. It was used for transferring equipment, supplies, and fuel drums from the airstrip on Lake Hazen to the site of the base camp on the lake shore, and for haulage around the lake. It gave very good service over three years. However, it has the disadvantage that its track width is different from that of the J-5 tractor.

Conclusion. In practice, the reliance on small vehicles and dogs worked out very well. Very little time was wasted on repairing vehicles.

It is useful to compare the weight of food needed for dogs, and the weight of fuel needed for an "Eliason" motor toboggan. A good day's sledging on the glaciers and névés of northern Ellesmere Island would average about twenty miles. For a team of ten dogs, this requires, at the rate of one block of "Nutrican" per dog per day, a sledge weight of only 10 lb. of food. The "Eliason" can do about 15 to 20 miles a gallon in the same circumstances. A gallon of fuel, with the container, weighs 10 to 12 lb. It would seem that

the two means of transport are of about equal efficiency, but the "Eliason" can be driven continuously, if necessary, whereas the sledge dogs must be rested periodically. On the other hand, the snow toboggans sometimes cannot be operated in difficult places on glaciers or in rocky valleys where dogs can go with ease, and where they still provide the best and sometimes only form of transport.

Clothing

Light Grenfell cloth parkas and roomy trousers, worn over woollen bush trousers and jackets with a down waistcoat, were standard clothing.

Footwear

Mukluks. Canadian Army mukluks were used from the end of April until the middle of June in temperatures down to −30° F. (−34° C.). Worn with double duffle socks and mesh and felt insoles, the mukluks were very warm, comfortable footwear. The soles are sufficiently rigid, and the tread good enough for the mukluks to be worn safely on quite steep slopes, or with crampons or skis. In this way they are superior to a sealskin boot or moccasin. Rubber ("Siple") socks were worn successfully under the duffles. With rubber socks the duffles did not have to be dried at night, and the feet were warmer. The mukluks must be of ample length in the leg, otherwise the drawstring comes around the calf instead of just below the knee, the mukluks soon slip down on the trail, and snow gets into the duffles.

Insulated rubber boots. These were of two types, and were used by all members of the party during the melt season. The Service type were excellent boots for spring and summer in northern Ellesmere Island. Their sealed insulation makes them rather too warm on the warmest days; on the other hand, it is desirable when feet are liable to get wet from stream crossings. The boots can be worn with snowshoes, skis and crampons, which makes them an excellent all-purpose boot; when used with crampons, however, great care must be taken that the insulation is not punctured by the spikes. The civilian type were much lighter than the army boots. They proved to be a comfortable boot for walking on the tundra, as well as on melting ice surfaces.

Tents

The "Jamesway" and "Attwell" shelters at Hazen Camp were the only permanent accommodation erected at Lake Hazen. Tents of various sizes were used by field parties working away from base camp, and by the glacier party. Comparative notes are given on the two larger tents in use.

Canadian Army lightweight 5-man Arctic tent. This hexagonal, centre-pole tent is useful as a store tent at a permanent or semi-permanent camp, but it is difficult to heat. Two of them were used at the glacier camp. They only had to be repitched once or twice during the season, but uncovered tent floors became hazardous as they turned to smooth ice; floors should be covered with heavy canvas.

During the melt period ¾ in. bamboo poles drilled 18 to 24 in. into the ice,

where they froze in, were used as tent pegs. These had to be reset about once a week during the height of the melt.

Pyramid tents. These were preferred to the 5-man tents for warmth and general comfort. They are shaped so that the maximum warmth is derived from the stove used in cooking. If necessary, they can be pitched by two men in a high wind.

Double-walled, 2-man pyramid tents were used as living quarters on the glacier during the summer of 1957. Inside the tent the separate ground sheet was spread out and covered with caribou skins with a sheepskin on top to provide extra warmth and comfort. The tents were left pitched on the glacier in August 1957, when the camp was evacuated, and it was considered preferable to cache scientific equipment inside them, rather than under tarpaulins. When the camp was reopened in May 1958, the tents were found to be in good condition with no drift over them, and they were used again during the second summer.

These tents, measuring 7 ft. by 7 ft. at the base, are essentially for sleeping two men. During the summer of 1958, 3-man pyramid tents were used as living accommodation on the Gilman Glacier; these, with a base area of 81 sq. ft., gave a feeling of spaciousness after the more restricted quarters in the 2-man tents.

Small two-burner naphtha stoves served for heating and cooking in the tents. During late June and July in both years, it was usual to sleep in the tents in a single sleeping bag, with the tent door open. "Windows" were made for the tent doors by stretching three layers of transparent plastic over a light framework.

Food

Standard grocery items made up the bulk of the expedition food. For the base camp, a large stock of assorted food was brought in on the first air lift, in April 1957. Each expedition member was asked to suggest additions to the food list. There were few requests for extra items; the basic food supplies provided a diet with plenty of variety for the parties working out from the base camp during the summers of 1957 and 1958, and for the four men of the wintering party. The high cost of air shipment precluded the flying in of items of high water content or of other than the best quality. The food flown in was supplemented during the summers by Arctic Char caught in the lake, by items from Canadian Army rations, and by some specially prepared dehydrated meats.

For the glacier party, rations were specially packed. All the items in the boxes can be bought at any provision merchants. The aluminium boxes in which the food was packed measured 13½ in. wide, 10 in. high by 21 in. long, and fitted between the longitudinals of the "Nansen" sledges. Each box was welded and made waterproof. When empty, these boxes were useful for holding clothing, notebooks, plant and rock specimens, and small items of trail equipment. The contents of these Daily Ration boxes, each weighing about 64 lb., were as follows:

4 lb.	sweet biscuits
6 lb.	butter
9 lb.	assorted chocolate bars
1 lb.	cocoa or drinking chocolate
6 oz.	instant coffee
1 lb.	dates
1 pkg.	egg powder (equivalent to 12 eggs)
1 lb.	dried fruit (mixed)
½ lb.	jar "marmite"
6 lb.	tinned meat (corned beef, ham, roast beef or bacon)
24	bouillon or meat cubes
2½ lb.	whole dried milk
6 lb.	quick cooking oats
1 lb.	potato powder
2 lb.	raisins
2 lb.	rice
12 pkg.	dried soups (assorted, 4 portion)
2 lb.	granulated sugar
2 lb.	sugar cubes
¼ lb.	tea

Each ration box was supplemented by 2½ lb. fruitcake, 5 lb. meat bars, 4 lb. pilot biscuits and 50 combined vitamin tablets, and provided a generous two-weeks' ration for two men. The latter items were packed separately.

The following additional groceries needed by the glacier party during the summers were also packed in aluminium boxes of the same dimensions. None of these boxes weighed more than 100 lb. Like the ration boxes, they presented no handling problems and could easily be carried and stacked.

Baking powder	Instant puddings
Cheese	Salami
Coffee	Salt
Curry powder	Sardines
Flour	Sausages
Garlic powder	Spaghetti
Lemon and orange juice	Tomato purée
Jam	Dried vegetables
Whole dried milk	Matches
Nuts	Pot scrapers
Pancake flour	Soap
Pea flour	Toilet paper
Peanut butter	Paper towels
Pepper	Ascorbic acid tablets

Suggestions for possible changes in this basic food ration, after the experiences of 1957–58, included the addition of more sugar, a variation in the tea to coffee ratio depending on individual tastes, the substitution of pilot biscuits for sweet biscuits, the addition of an extra tin of dried eggs, the inclusion of drinking chocolate instead of cocoa in some boxes, and the elimination of bacon from the boxes. Breakfasts usually consisted of porridge or scrambled eggs, lunches of soup (when in camp), meat, shortbread bars and chocolate, and suppers of a stew, spaghetti with meat sauce, or some other substantial item. There were few complaints about the food, and, although a limited amount of preparation was required, tasty filling meals were the rule at the glacier camp.

Some dehydrated meat, supplied by the Canadian Defence Research Medical Laboratories on an experimental basis, made a valuable and welcome addition to the rations. During 1957, dehydrated steaks, pork chops and chicken were

eaten by the members of the summer party. The steaks were eaten both at the main camp and at the Gilman Glacier camp. The instructions "soak in water for five minutes and cook as fresh steak" were followed, and the steaks were always fried, rather than grilled. With a little flour and water, quite a good gravy was made in the frying pan. The steaks were equally good whether fried over the oil-burning stove at base camp, or over a naphtha stove in a tent. It was found that the rib steaks were generally more tender than the round steaks, but the round steaks were certainly not tough. Towards the end of the summer, the fat on the steaks was inclined to be a little rancid, but there was so little fat on any of them that little was lost if it was trimmed off. During 1958, dehydrated minced beef and minced pork were added to the rations and were used in stews with dried vegetables, or prepared as patties; they also proved to be very tasty and were much appreciated. The value of such items is not to be measured only in their food value and palatability; at an isolated station there is considerable morale value in serving steaks and other forms of dehydrated meats that are virtually undistinguishable from fresh products.

Three items from Canadian army rations gave quick nourishment in palatable form. These were meat bars, oatmeal bars and shortbread bars. Meat bars were extensively eaten during the whole period of the expedition and probably made up half the meat intake at the glacier camp. They were palatable in stews, especially when flavoured with onion or a little curry powder, and an excellent sauce for spaghetti could be made with them. They were frequently eaten from the packet on the trail. Oatmeal blocks made another good item for trail lunches, but they were less popular than the shortbread bars for quick nourishment, as they tended to be harder to eat. Shortbread bars were a staple item of trail lunches. The packaging in cellophane is perfectly adequate for Arctic conditions.

Fruitcake, specially prepared to the specifications of the Canadian Defence Research Medical Laboratories, was also eaten in camp and on the trail, and made a rich supplement to the daily rations. It proved to be very filling, very palatable, and a useful way to get quick energy on the trail, or after a hard day. The only criticism of this excellent cake is that more than a small amount of it is too rich for some tastes. This is the way the cake is designed, and it is an excellent survival ration. Rum soaking improved the keeping quality of the cake, and some cached in 1957 on the glacier was in perfect condition in 1960.

Conclusion

Since the end of the IGY Hazen Camp has been used as a base for small-scale scientific investigations. The camp is ideally situated for a variety of field investigations as its re-supply on a modest scale can be readily carried out by icebreaker in late summer, or by airlift in the spring.

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ESKIMO COMMERCIAL FISHERIES

BY DONALD SNOWDEN*

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Arctic char, long a favourite food with the Eskimos, has recently been finding a ready market throughout Canada and the United States. With the increasing concentration of Eskimo populations in settlements, and with their increasing dependence on "white man's" food and equipment, it has become essential to stimulate means of increasing cash income. It was with this in mind that the Department of Northern Affairs and National Resources carried out an experimental project to introduce Arctic char to the southern market in 1958. During the season, about 1,500 lb. were shipped on ice to Montreal and Toronto by air, and were distributed to a number of the best restaurants. Its reception by customers was so enthusiastic that a repeat order for more than the original 1,500 lb. was received in a matter of days.

Once it had been established that Arctic char, carefully handled and processed, would find a "carriage trade" market in southern Canada and the United States, it was decided to make plans for the construction of permanent handling and processing facilities in the eastern Arctic. In the autumn of 1958, commercial freezing equipment was ordered and sent to Frobisher Bay to be ready for the short summer fishing season in 1959. The Federal Department of Fisheries had already carried out a programme of biological research in the Sylvia–Grinnell River at Frobisher Bay, and had established a quota of 12,000 lb. for the commercial fishing operation. A total "safe yield" from the river was estimated at 48,000 lb. a year. Much of it, however, was to be reserved for consumption by local Eskimos, and some for the growing number of sport-fishermen who visit Frobisher during the summer. As the commercial fishery for Arctic char was still in the experimental stage, it was carried out in 1959 as a prototype project under the aegis of the Department of Northern Affairs.

At the same time, investigations in the eastern Ungava Bay area of northern Quebec had indicated that the prospects for the establishment of a commercial char fishery there looked highly favourable. Very little was known biologically about the area, so a biologist from the Quebec Department of Game and Fisheries and a student assistant were sent to George River during the summer of 1959 to begin a continuing research programme. During the early spring of 1959, officers from the Department's Industrial Division visited the Ungava area to discuss the possibility of a commercial fishery with the Eskimos in the George River area. In this remote part of northern Quebec about 110 Eskimos make their living almost entirely from the land as hunters and fishermen. The family income is exceedingly low and probably averages

* Chief, Industrial Division, Department of Northern Affairs.

$300 per year, including family allowance payments, which are the main source of income for many of the families there. These people had never before been involved in a commercial fishing operation and, indeed, knew little about commercial fishing operations anywhere. They are, however, industrious and hardworking, keen to learn and to try new projects which will enable them to enjoy a more comfortable living in the area which is their home. After discussion, they decided to apply to the Department of Northern Affairs and National Resources for a loan, under the Eskimo Loan Fund which it operates, in order to form their own fisheries co-operative. Permission was obtained from the Quebec Department of Game and Fisheries to begin operations in 1959 with a tentative quota of 30,000 lb. At the same time, a small group of Eskimos at the Port Burwell settlement, on the extreme north-east tip of Ungava Bay, also requested an opportunity to engage in commercial char fishing. Following the meeting with these two groups of people, freezers capable of processing and handling approximately 20,000 lb. each were ordered for both George River and Port Burwell. They were carried in by ship in July, though, because of faulty equipment, the Port Burwell fishery was not put into operation during 1959. By 4 August the George River freezer was constructed, the Eskimo fishermen in the co-operative began to set their nets for char, and the first Eskimo-owned and operated fishery in the Canadian Arctic was under way.

Twenty Eskimos worked in the commercial fishery, three being employed full-time—two on the boats and one working with the freezer operation. In addition, two boys and two young women were hired to work at the freezer, cleaning char and doing other related tasks. The fishing was carried out at the estuary of the George River within a radius of 50 miles of the freezer. Two boats were used, each making two trips every 24 hours. Because of high tides, fishing was done only during the incoming tides, for at low tide the nets could be up to 600 yd. from the water's edge. The fishing operations were carried on between 4 and 28 August, with up to 1,800 lb. per day being taken, and when they ended 18,600 lb. of char had been caught and the freezer was full. The fish were cleaned, flash-frozen, glazed and boxed. Although traditionally the Eskimos had been used to very rough handling of fish, they took great care to see that every fish shipped to southern Canada was carefully handled so that it would arrive at the Montreal market in perfect condition. An initial payment was made to the Eskimos working at the fishery during the summer of 1959 and, when all fish shipped south were sold, a final payment was made. In addition, part of the revenue from the fishery will go toward paying off the loan taken by the Eskimo co-operative to purchase freezers and equipment for the fishery.

At Frobisher Bay the freezer was set up about half a mile from the beach. Eight Eskimo fishermen took part in the operation under the direction of an officer of the Northern Affairs Industrial Division, and were paid on a direct wage basis by the Federal Government. They worked in four crews of two men each, and the fishing was divided between morning and evening tides; this was necessary because the tides are 42 ft. high and the best fish runs were

at these times. Two canoes were used and each one brought in approximately 100 fish at a time, averaging 300 to 400 lb., and making a total of approximately 1,600 lb. per day. As soon as the fish were taken from the nets, they were placed in covered boxes on the canoes in order to protect them from the sun and from any other possible damage. For the most part, the fishing was carried out in the vicinity of the Sylvia–Grinnell River. Nylon nets with a $4\frac{1}{2}$-in. mesh were found to be most effective. Fishing in Arctic waters posed some added problems. Each time the canoes returned with one period's catch, it was necessary to lift the nets so that they would not be damaged by drifting ice, and to avoid the accumulation of dirt and sea-weed. The 1959 fishery operation lasted only ten days to two weeks in August, although the char fishing season ran between mid-July and mid-August. However, because of the efficiency of the eight Eskimo fishermen and the four Eskimo girls who did the cleaning and processing, the fishery reached its 12,000 lb. quota within a very short time. The fish were frozen in a flash freezer, glazed, boxed and shipped by sea to a commercial fish broker in Montreal. When the fishing season ended, it was found that the average size of the char taken was 4·71 lb.

Marketing of the fish is being carried out jointly by the co-operatives and the Industrial Division of the Department of Northern Affairs and National Resources. During the summer of 1960 freezers were in operation at Port Burwell, George River and Frobisher Bay. The three fisheries produced about 46,000 lb. of fish during 1960. Both the George River and Port Burwell fisheries were operated by Eskimo co-operatives in the 1960 season.

The financial return to the Eskimos involved in these fisheries has already been a major factor in raising their standard of living and enhancing their self-esteem. The Department of Northern Affairs hopes to assist Eskimos to establish char fisheries in other areas, and the Indian Affairs Branch, Department of Citizenship and Immigration, also plans to ship out some char from the Cape Jones area in Hudson Bay.

FIELD WORK

ANTHROPOLOGICAL STUDIES IN NORTH-WEST GREENLAND, 1959

[Summarized from information provided by B. Jensen and K. Taylor.]

During the summer of 1959, B. Jensen continued his anthropological work among the hunting community of Umánaq district, north-west Greenland. This community numbers about 1800 and lives in the town of Umánaq, seven outposts and two single family dwelling places in the vicinity. The area is still comparatively unaffected by outside contacts, and can reasonably be treated as a self-contained unit for physical, social and cultural studies.

Jensen began his work in Greenland by spending a year, 1955–56, in the Godthaab district, and the following year moved north to settle for 1956–57 at Ikerasak, an outpost about 40 km. south of Umánaq. Here he supported himself as a member of the hunting community and moved about the area getting to know all the inhabitants, their mode of life and everyday speech. He eventually was able to buy the two-roomed turf hut he had rented during the winter. He then returned to Denmark and spent the next two years at the University of København, returning to field studies in the same area in July 1959.

That summer he was joined by K. Taylor, a Scottish canoeist, and they began a study of kayaks and kayaking; Taylor working on the technical and material aspects and Jensen on the sociological and historical. Jensen also collected a considerable amount of information on local customs, folklore, traditions and sledge-dog culture.

Both men returned to Denmark at the end of the summer and plan to return in 1961.

ACTIVITIES ON ICE ISLAND T-3, 1959–60

[By Irene M. Cotell, Geophysics Research Directorate, Headquarters Detachment 2, Air Force Research Division.]

Since August 1959, T-3 has been drifting in a westerly direction across the Beaufort Sea, almost continually within 100 miles of the coastline of Canada or Alaska. The scientific programme progressed without interruption throughout the period.[1] Data and samples collected are now being processed to obtain a comprehensive geophysical description of the continental shelf region north of Canada and Alaska.

On 2 September 1959, USS *Staten Island* anchored for a brief visit; it was the first surface vessel to visit the island. Air traffic to the island was still suspended owing to melt deterioration of the ice surface, so data, mail and equipment were exchanged and several scientists left the station.

The first of three fires occurred on 1 December 1959 in the main camp area. It started in the small portable shelter housing the island's power generators. The day fuel tank was caught in the fire, but the main fuel supply tank was successfully isolated. Snow, piled up by a caterpillar bulldozer as a container wall next to the burning building, was extremely effective in confining the fire and protecting other camp structures, though two 40 kW. generators and the power shelter were destroyed. A new diesel generator was installed and in operation three days later. The second fire, on 28 January 1960, burnt out the seismology laboratory which was in a James-

[1] *Polar Record*, Vol. 10, No. 66, 1960, p. 269–74.

way shelter at the edge of the pack ice, about half a mile from the main camp. The laboratory was unoccupied at the time. The third fire destroyed the replacement seismic laboratory on 16 April 1960, together with all its contents.

Several landings were made by Cessnas 180 and 195 on the pack ice to the north and south of T-3 during April and May. Explosives were detonated to set up refracted seismic waves for recording on the ice island. Distances up to 35 miles from T-3 were explored, and nearly all the detonations were successfully recorded. The results are now being analysed to determine the topography of the continental shelf in the area.

In early May, visitors to T-3 brought the disturbing news that a section, roughly triangular in shape and measuring about 4 sq. miles, had broken off the main island. The break was along a line between the island prominences known as "Flat Hill" and "Neher Hill". Along the separation the cliffs of T-3 ice rose 20 to 30 ft. above the ocean surface and the banded dirt layering, typical of the upper ice structure of T-3, was clearly exposed. Two craters, undoubtedly formed during the break-off by the collapse of the roofs of ice caverns, were visible in the ice cliff; these features most probably originated as embedded melt water lakes. Shortly before the discovery of the break, the depth of water recorded in lat. 71° 50′ N., long. 159° 29′ W. was only 151 ft., or approximately the same as the draught of T-3. Presumably the island had touched bottom producing the tension break. In the next few days, the island shifted position about 15 miles and the water depth increased to 168 ft. On 20 May it was noted that the island had rotated 100° in 72 hours. The ocean depth had decreased to 148 ft., suggesting that the island might have been pivoting on a high bottom point. On 24 May the position was lat. 71° 50′ N., long. 160° 20′ W. and frequent sun fixes and depth readings during succeeding weeks verified that the island was stationary in about 140 ft. of water. Thirty pieces of floating T-3 ice, scattered over a 50 sq. mile area, were sighted as shattering of the ends of the island persisted. On 16 July, under strong winds, the island was freed and drifted 6 miles to the south-east. The fragment containing the prominence "Neher Hill" remained stationary.

The avenue of escape for T-3 from its present position is movement eastward and then northward. During the period of no drift, observations that depended on change of position for significance were reduced in number. Ice physics and ice structure investigations, however, were greatly improved by the natural exposures caused by the breaks. The meteorological, micrometeorological, ablation and surface topographical studies were not affected. The oceanographical programme was oriented toward a study of the effects of surface meltwater run-off. Marine biological studies continued as before, but the seismic programme of submarine geophysical exploration was temporarily suspended until the island was again afloat.

SCOTTISH SPITSBERGEN PHYSIOLOGY EXPEDITION, 1960

[Summarized from a note by H. Simpson.]

A party of eleven, led by Dr H. Simpson and including Dr Mary Lobban, spent about two months in and around Brucebyen, Vestspitsbergen, during the summer of 1960. The main object of the expedition was to study the effect of a 21 hour daily routine on the human adrenal cortex by estimating the urinary total 17-hydroxy-corticosteroids. In addition to the urine samples retained for corticoid analysis, duplicates were taken for determining sodium, potassium and chloride concentration and the pH value. A mental acuity test was also carried out to investigate any impairment which might result from this routine. The experiment continued for

seven weeks, and afterwards specimens were collected on normal time to test re-adaptability. On the return of some of the party from the ice cap, specimens were again taken to examine any effect of exercise and stress on diurnal rhythm of the adrenal cortex, electrolytes and urinary pH.

Some of the party sledged for some 135 miles on the ice cap and climbed a number of peaks.

A plane table survey was made of the 1960 margin of the Nordenskjöldbreen. Retreat was maximal near the south shore, being 700 yd. since 1949, and 1800 yd. since 1908.

A number of journeys were also made by canoe or on foot, totalling about 300 miles.

The party left Spitsbergen on 5 September.

OIL RECONNAISSANCE IN SPITSBERGEN, 1960

[Summarized from a note provided by American Overseas Petroleum Ltd.]

Two parties of geologists carried out a preliminary reconnaissance in Spitsbergen, during July and August 1960, to assess the possibilities of oil-bearing areas in the islands. They were sent by American Overseas Petroleum Ltd., one of the Caltex group of companies, and were led by H. D. Klemme and A. S. Westerholm. Two helicopters were used.

No definite results have yet been published, but tentative plans have been made to continue the survey in 1961.

INTERNATIONAL GLACIOLOGICAL EXPEDITION TO GREENLAND, 1957–60: ACTIVITIES IN 1960

[Summarized from information supplied by Expéditions Polaires Françaises. Accounts of earlier activities appeared in the *Polar Record*, Vol. 10, No. 65, 1960, p. 139–41, and previous issues.]

The 1960 summer party of twelve men, led by Paul-Émile Victor, arrived in Söndre Strömfjord by air on 11 May. It was accompanied by two helicopters and their crews. The objects of the season's operations were to continue the previous season's programme of geodesy, glaciology and meteorology, to relieve the winter party at "Jarl-Joset", and to close down the affairs of the expedition in Greenland.

Between 12 May and their return to France at the end of the month, the helicopters carried supplies to "Jarl-Joset" and generally supported the overland party. The expedition's transport aeroplanes also made a number of air drops of supplies.

The overland party, led by R. Guillard, set out on 16 May and followed the previous season's route, collecting supplies at "Jonction" and "Point Sud" and reaching "Camp VI" on the 27th. On 4 July it set out for "Jarl-Joset", arriving on the 13th. A fortnight was spent there and the station was closed down when the party returned to "Camp VI". This station was then also closed and the party of seventeen men, with fifteen weasels and other vehicles, moved towards the United States radar station "DYE 2", which was reached on 21 August. The party maintained regular scientific observations throughout the season's journeys.

From "DYE 2" twelve United States C120 aeroplanes transported the party, and 65 tons of matériel, to Söndre Strömfjord. Members of the expedition returned from there to France by air on 5 September, and heavy matériel followed by sea.

CANADIAN OPERATION "HAZEN", 1960[1]

[By G. Hattersley-Smith, Geophysics Section, Defence Research Board.]

In the spring of 1960 the Defence Research Board of Canada carried out a limited programme of glaciological, meteorological and soil research from Hazen Camp on the north shore of Lake Hazen, where a Canadian IGY–IGC station was established in 1957.[2] G. Hattersley-Smith (glaciologist), J. R. Lotz (meteorologist), and R. Yong (soil scientist), arrived at Hazen Camp on 20 May in a ski-wheel DC-3 ("Dakota") aircraft of 102 Composite Unit of Air Transport Command, RCAF. Two days later Hattersley-Smith and Lotz were landed at the 1957–58 camp site on Gilman Glacier at an elevation of 3400 ft. (1040 m.). The same day Yong returned south with the Dakota, taking with him a collection of soil samples for laboratory analysis. During the next three weeks the glacier party, travelling by "Eliason" motor toboggan, revisited about 50 stakes set up in previous years. The stakes were located between the glacier terminus at 1350 ft. (415 m.) and an elevation of 5400 ft. (1660 m.) on the ice cap, a distance of 25 miles (40 km.); in the ablation zone it was necessary to drill them more deeply into the ice. Two, and in some cases, three years data on accumulation and ablation are now available from these stakes. Meteorological observations were maintained at the Gilman Glacier camp; in comparison with the three years 1957–59 the spring proved to be very warm. On 9 June a maximum shade temperature of 46·2° F. (7·8° C.) was recorded; the previous maximum recorded in the first two weeks in June had been 42·1° F. (5·6° C.) in 1957. On 12 June Lotz and Hattersley-Smith were evacuated by a DC-3 aircraft of 102 Composite Unit. The melt had already started at the camp, and conditions on the glacier for ski landing and take-off were not good. The aircraft left directly for Thule Air Base since it proved impossible to land on the lake ice near Hazen Camp on the way, as had been planned. The snow on Lake Hazen was by this time slushy, and the ice was beginning to melt and crack. The DC-3 aircraft on both flights to Lake Hazen was commanded by F/Lt. H. R. Nicholson.

SUBMARINE TOPOGRAPHICAL STUDIES IN THE QUEEN ELIZABETH ISLANDS, 1960

[By M. Marsden, Arctic Institute of North America.]

In the course of geomorphological studies over a period of eight years it had become clear that a possibility existed of former morphological cycles below the present sea level in the northern Arctic areas of Canada; these would now show a submarine topography which could be related to the present surface topography of the islands. In order to begin investigations in this field it was necessary to develop sounding equipment which would give accurate responses at pre-determined locations in areas normally covered by heavy sea ice, or by loose floes which would hamper movement by conventional means. After discussion with Dr E. R. Pounder of McGill University, it was decided that a conventional echo sounder with a conventional transducer would be completely effective for work through the ice without making drill-holes, if it were possible to effect a good contact between the transducer and the ice surface. Kelvin & Hughes (Canada) Limited kindly lent equipment for the initial experiments on the lake at the McGill Research Station at Mount St Hillaire,

[1] Published by permission of the Chairman, Defence Research Board of Canada.

[2] For an account of the I.G.Y. and I.G.C. research from Hazen Camp (Operation "Hazen") see *Polar Record*, Vol. 9, No. 58, 1958, p. 26–27; Vol. 9, No. 62, 1959, p. 455–58; Vol. 10, No. 64, 1960, p. 44–45.

Hazen Camp on north shore of Lake Hazen, showing "Attwell" shelters (white) and "Jamesway" shelters (black)

RCAF photograph

(*Facing p.* 388)

General view of the Lake Hazen area from the north-east, with the ice cap in the top right and Hazen Camp marked "C"

RCAF photograph

Quebec, and Canadian Industries Limited provided a number of polythene pads containing various saline solutions and oil. Tests indicated that a signal could be sent through fresh-water ice in order to give an accurate depth reading. The pads provided a good contact between the transducer face and the ice, but proved unnecessary in the long run, since a direct contact with the ice proved satisfactory with the addition of a saline solution.

It then became necessary to test the equipment on sea ice and in much greater depths of water than were available at the first test site, and it was decided to attempt to carry out the field studies of submarine topography at the same time.

The Canadian Hydrographic Office lent an MS29M echo sounder. This machine uses a brick-shaped magneto-striction bar type transducer, which functions both as a transmitter and receiver, and has a range of 880 m. With the aid of a Banting Grant from the Arctic Institute of North America, a journey was undertaken from Resolute, Cornwallis Island, to the fjord region of south-western Axel Heiberg Island, where the desired topographic studies were to be made. The journey was by dog sledge and covered the ground between the two areas for very specific reasons. It was important to test the equipment on all varieties of sea ice before committing the party to an expensive flight into a remote area; the journey to Axel Heiberg Island allowed this and, at the same time, provided a good test of mechanical reliability under rough conditions. Also, hydrographic information from the channels west of Cornwallis Island and north of the Grinnell Peninsula, Devon Island, had a value in itself.

After preliminary tests comparing ice and water soundings in a drill-hole in Resolute Bay, M. Marsden and two Eskimos, Samuelie and Andrew, left Resolute on 13 April with two sledges and began observations through the sea ice on the 15th. The first series of soundings produced channel cross-sections with readings at one-mile intervals, as determined by a sledge wheel, and were completely successful. A check was provided at one location by soundings being made both through ice and through an adjacent seal hole. This test indicated identical readings through ice and through water, with a stronger response through ice. In the course of the three weeks journey to Cornwall Island a technique for using the equipment was developed, and in this early period there were only three failures to obtain results at any of the chosen locations, in spite of all varieties of conditions including extremely rough shattered ice.

The Eskimo with the supporting sledge left a cache of food and fuel on Cornwall Island and set off back to Resolute on 3 May. A programme of soundings was then carried out in the two channels separating Haig-Thomas Island from Amund Ringnes Island, and a section was taken across the 27 miles of channel between Amund Ringnes Island and Cape Maundy Thursday on Axel Heiberg Island.

Bad weather, and the failure of an attempt to link with the Jacobsen–McGill Axel Heiberg Island Expedition on South Fiord, then led to a serious loss of time, but a complete set of profiles and sections of Sand Bay, in western Axel Heiberg Island, was made with soundings at intervals of a few hundred yards, during the last weeks of May and early June. Results indicated submarine profiles resembling fjord sections, and that the valley of Sand Bay ends in an underwater hanging valley. The maximum depth recorded was 726 m.

On 2 June the party turned back to Resolute by way of the eastern side of Cornwall Island, Arthur Fiord, and Wellington Channel, without carrying out any sounding work en route. Ice conditions were good for travel in spite of surface melt and some large cracks near Resolute.

A cache left by Captain Sir Edward Belcher in 1853 was found in Northumberland Sound on Grinnell Peninsula. A lead plate bearing a message, and a roll of papers in poor condition, have been given to the Department of Northern Affairs, but no

attempt was made to open the large cairn. Many empty tins from that expedition's stores litter the site. Another message in a metal tube was found in June on the height of land between Arthur Fiord and Wellington Channel. It was also in poor condition and is yet to be opened by a museum's expert. No author is known for the second note but it is possibly another Belcher record.

The party reached Resolute on 21 June and Marsden flew south with an RCAF airlift at the end of the month.

UNDER-ICE PASSAGE OF McCLURE STRAIT, 1960

[Summarized from the *Times*, 24 August 1960 and *Stars and Stripes*, 26 August 1960.]

Between 15 and 21 August 1960, USS *Seadragon*, Commander G. P. Steele, the 2360 ton United States nuclear submarine, followed the North-West Passage from East to West. The route followed was through Lancaster Sound, Melville Sound, and under ice through McClure Strait to emerge in the Beaufort Sea. It then made for the North Pole, and south through Bering Strait to the Pacific Ocean.

In addition to a ship's complement of eighty-three, there was a group of scientists on board. During under-ice passages TV-screens were used to follow the configuration of the ice overhead.

ARCTIC INSTITUTE OF NORTH AMERICA DEVON ISLAND EXPEDITION, 1960–63: ACTIVITIES IN 1960

[Summarized from information received from S. Appolonio.]

The objects of the Arctic Institute of North America Devon Island Expedition are (*a*) a detailed study of the relationships between the ice cap, atmosphere and adjacent marine waters (Jones Sound) of Devon Island with regard to heat budget, mass balance and energy transfer; (*b*) a study of the oceanography and marine biology of Jones Sound, with particular attention to the effects of the Devon Island glaciers; and (*c*) detailed studies of the archaeology and geology of Devon Island.

The 1960 party was led by Spencer Appolonio, and included C. R. Harington (naturalist), G. R. Lowther and R. S. McCall (archaeologists), D. R. Oliver (zoologist) and three engineers. The principal object of this party was to establish two stations, one at sea level and one on the ice cap ready for use by the main party during 1961. They travelled in the *d'Iberville*, disembarking on 21 August at a point about 15 miles south-west of Cape Skogn on the north coast of the island. The main base, consisting of three prefabricated huts, was established near a small lake a mile inland. A feasible route to the ice cap for tractors and weasels was discovered.

Two archaeological sites were examined, one probably Thule or Central Eskimo culture, and a second, near Cape Sparbo, showing signs of successive cultures from pre-Dorset.

The party left on 11 September and returned via Thule.

BELGIAN ACTIVITIES IN ANTARCTICA, 1958–60

[Summarized from information supplied by Commandant F. E. Bastin.]

The 1959 wintering party was led by Capitaine F. E. Bastin (meteorologist) and consisted of twenty-one members, including one Englishman (K. Blaiklock, surveyor), one Frenchman (G. Dieterle, seismic physicist) and a United States observer,

O. S. Crosby. Belgian scientists were: A. Keleciom (ionosphere), R. Ketelers and P. Suetens (nuclear radiation), J. Van Baclen, A. Vandenbosch and A. Vanderschueren (also solar radiation and atmospheric electricity) (meteorology), I. van Decan (biology, glaciology), T. van Autenboer (geology, gravimetry), and G. Verjaillie (geomagnetism and physical chemistry).

The party left Ostend on 15 November 1958 and reached the pack ice on 22 December, becoming beset three days later. In response to a radio appeal, USS *Glacier* reached them from the Ross Sea on 4 February 1959, but failed to open a passage; the expedition, with its supplies and equipment, was taken aboard the *Glacier* and finally reached Breidvika on 19 February. *Polarhav* was left at the edge of the pack ice with USS *Edisto* standing by until the return of the *Glacier* carrying the Belgian 1958 winter party.

Early in March a sledge journey was made to reconnoitre a route to the plateau; this was discovered by way of "Gunnestadbreen" in Sör Rondane and a fuel depot was established for use during the summer journeys. On the return 3 of the 5 Sno-cats had to be abandoned owing to bad weather and fatigue of the party: they were recovered early in September. The main sledging party, consisting of 3 Sno-cats and 2 dog-sledges, left "Base Roi Baudouin" in November, surveyed the western ranges of the Sör Rondane mountains, and examined a number of glaciers to find other routes to the polar plateau. Seismic shots were made throughout the journey from the base and in a line across the seaward parts of the main glaciers. The Sno-cat party returned to base by 27 December while the dog-sledge party remained in the Sör Rondane mountains until 1 May 1960.

The scientific programme was successfully completed with the exception of auroral panoramic photography. It included 690 radio-soundings reaching an average height of 45 mb. and an absolute height of 11 mb., or 29,500 m., also observations in a 25 m. glaciological pit.

The relief and re-supply ship *Erika Dan* arrived on 22 January 1960 and, during her 19-day stay, photogrammetric survey flights were made along the coast and over the Sör Rondane mountains.

THE FALKLAND ISLANDS DEPENDENCIES SURVEY, 1958–59

[Summarized from information provided by the Colonial Office. An account of the activities of the Falkland Islands Dependencies Survey (FIDS) in 1957–58 was published in the *Polar Record*, Vol. 10, No. 64, 1960, p. 46–54.]

During the winter of 1958 eleven British stations were occupied by FIDS parties: Signy Island in the South Orkney Islands; Whalers Bay, Deception Island, and Admiralty Bay, King George Island—both in the South Shetland Islands; Hope Bay, Trinity Peninsula; Port Lockroy, Wiencke Island, in the Palmer Archipelago; Dance Island, Argentine Islands, Prospect Point, Detaille Island, Horseshoe Island and Stonington Island—the last six off west Graham Land. Work also continued at the meteorological station at Grytviken in South Georgia.

Summer operations, 1958–59

RRS *Shackleton*, Captain J. F. Blackburn, arrived at Port Stanley, Falkland Islands on 5 November and left on her first southern voyage on the 15th. After relieving the Signy Island and Hope Bay stations, she reached Admiralty Bay on the 28th. Shortly after her arrival, pack ice drifted into the bay and damaged her rudder stock. After temporary repairs, she sailed for Deception Island where further repairs enabled her to proceed to the relief of stations in Gerlache Strait. She visited

the Portal Point hut on Reclus Peninsula, Dance Island and Port Lockroy before returning to Hope Bay to transfer a survey and geological party to Joinville Island. This party, consisting of J. S. Bibby, D. G. Evans, L. Rice and R. W. Tufft, remained on the island until March. A number of localities in the South Shetland Islands were then visited in connexion with the work of summer parties. The *Shackleton* returned to Port Stanley on 18 January 1959 and sailed for Montevideo for dry dock repairs, remaining there for two months.

Professor D. Linton of Birmingham University and D. J. H. Searle accompanied *Shackleton* in order to make physiographical observations. They visited six FIDS stations in the South Orkney and South Shetland Islands and northern Graham Land. In addition, they made thirty-four landings at other coastal points, remaining ashore for up to 12 hours, and observed selected stretches of coast from the ship.

Meanwhile, RRS *John Biscoe*, Captain W. Johnston, reached Port Stanley on 17 November and sailed for South Georgia on the 24th. Between 28 November and 19 December the triangulation and hydrographic survey of Gold Harbour was completed at a scale of 1 : 30,000 by Commander J. C. Grattan.[1] *John Biscoe* returned to Port Stanley on the 22nd.

Tottan, Captain Leif Jakobsen, which had been chartered by the Royal Society for the relief of Halley Bay, reached Port Stanley on 23 December. She sailed on the 26th, called at South Georgia, and arrived at Halley Bay on 10 January 1959. On the 14th the station was transferred to FIDS administration.

John Biscoe left on her second southern voyage on 5 January. After brief visits to Deception Island, Livingston Island, Admiralty Bay, Hope Bay and Dance Island, she relieved the Argentine Islands station on the 16th. She then visited Flandres Bay where P. H. Grimley made geological observations. On the 22nd she sailed for Prospect Point, but was stopped by ice in Grandidier Channel. During the next two weeks all attempts to reach this station were unsuccessful and it was decided to return to Port Stanley. The Governor of the Falkland Islands and a United States observer, M. Sigismund, accompanied *John Biscoe* during the first part of this voyage.

A biological party under F. O'Gorman worked on Livingston Island between 10 January and mid-March 1959. They were landed in Barclay Bay by the *John Biscoe* and were flown out by HMS *Protector*'s helicopters. Their work included the investigation of Fur Seal and Elephant Seal colonies on the island.

John Biscoe left on her third southern voyage on 16 February. She evacuated the Dance Island station on 22nd, and, on the 24th and 25th, Prospect Point. She then sailed to relieve the Detaille Island station. On reaching Matha Strait, she was again held up by fast ice.

The continuing bad ice conditions and the damage to the *Shackleton* had by this time seriously delayed the relief programme. It was also becoming clear that *John Biscoe* would be unable to reach the southern stations unaided. The United States were therefore asked for the help of an icebreaker. On 2 March *Northwind* joined *John Biscoe* in Matha Strait. After further unsuccessful attempts to reach Detaille Island, it was decided to relieve the Horseshoe Island and Stonington Island stations first. Both ships reached a position five miles south of Jenny Island in northern Marguerite Bay on the 7th. During the next three days the Horseshoe Island station was relieved and re-supplied by American helicopters; Stonington Island was evacuated, its members having sledged to Horseshoe Island. Bad weather and ice conditions delayed the return of the *Northwind* and *John Biscoe* to the Detaille Island area and towards the end of the month they were still held up in the vicinity of the Sillard Islands. Another United States icebreaker, *Edisto*, had by this time reached

[1] Now published on Admiralty chart 3585, 27 November 1959 edition.

the vicinity of Anvers Island on her way to South America and her captain attempted to join *Northwind* and *John Biscoe* in Matha Strait. This proved impossible and when the weather also prevented the re-supply of the Detaille Island station by helicopter, evacuation was the only practical alternative. Members of the station sledged from Detaille Island to *John Biscoe*, which then sailed for the Argentine Islands with *Northwind*. They were joined by *Edisto* and, having failed to break through to the Argentine Islands by way of French Passage, went on to Port Lockroy on the 7th. With the help of the icebreakers, the relief of that station was completed. *Northwind* then left for South America. *Edisto* and *John Biscoe* reached Deception Island on the 10th, the former sailing the same day for Buenos Aires. After taking aboard some stores from *Shackleton* at Deception Island, *John Biscoe* visited Hope Bay, Signy Island and South Georgia before finally returning to Port Stanley on the 27th.

Shackleton returned to Stanley and sailed on her second southern voyage on 4 March. She carried with her a final cargo of stores, some of which were transferred to *John Biscoe* at Deception Island. She also visited Admiralty Bay before returning to Port Stanley on the 14th.

Shackleton sailed again on 30 April for South Georgia, returning to Port Stanley on 9 May and finally left for the United Kingdom on 12 May. *John Biscoe* left on the 14th.

The activities of the South Georgia Biological Expedition, 1958–59, which returned to the United Kingdom on the *Shackleton*, have already been summarized.[1]

Visit of British naval guardship, 1958–59

During November and December 1958 HMS *Protector*, Captain A. R. L. Butler, R.N., was prevented by ice from reaching Port Lockroy and Deception Island but succeeded in paying a short visit to South Georgia.

She sailed on her next southern voyage on 5 January 1959, with a tellurometer survey party on board. On the 9th, members of this party were landed by helicopter on Livingston, Snow and Deception Islands, and the Royal Marine detachment on Livingston Island. On the 14th, Professor Linton was landed at various points in the South Shetland Islands to examine the geomorphology of the area: he was taken finally to Admiralty Bay where he boarded *Shackleton* for Port Stanley. *Protector* then returned to Deception Island to support the tellurometer survey party. On the 18th the Governor was transferred from *John Biscoe*, the Royal Marines were re-embarked, and *Protector* sailed for Port Stanley, arriving on the 21st.

She sailed on her next southern voyage on 26 January. On the 29th the tellurometer link through Greenwich, Robert and Nelson Islands was completed and she sailed south to southern Gerlache Strait. Her two helicopters then flew to the Argentine Islands and thence made an ice reconnaissance for *John Biscoe* from French Passage to the vicinity of Pendleton Strait. Contact was also made, by air, with Port Lockroy and Dance Island. She returned to Port Stanley on 4 February.

Throughout its work, the tellurometer survey party was supported by *Protector*, all movement of surveyors and their equipment between survey stations being carried out by her helicopters. The survey party was led by G. F. Reid assisted by four FIDS surveyors, N. A. G. Leppard, C. A. Murray, C. G. Brading and J. C. A. Stokes, and by K. Allen, a general assistant and mountaineer. The primary object was to observe a connexion across Bransfield Strait between the South Shetland Islands and northern Graham Land. This was carried out by tellurometer trilateration, fifteen sides being measured from Livingston Island via Snow, Deception, Low and Trinity Islands and the Christiania Islands to northern Gerlache Strait. In addition, existing triangulation on King George Island was linked by tellurometer traverse

[1] See the *Polar Record*, Vol. 10, No. 65, 1960, p. 145–46.

across Nelson Strait to existing triangulation in the western South Shetland Islands. In southern Gerlache Strait a check measurement between Useful and Breakwater Islands was made for one side length in the ground control previously established by the Falkland Islands and Dependencies Aerial Survey Expedition in 1956–57.

Protector sailed on her last southern voyage from Port Stanley on 8 March. Between the 12th and 23rd, the survey and geological party on Joinville Island were returned, with their equipment, to Hope Bay; the biological party on Livingston Island was evacuated to Deception Island; a geological party from Admiralty Bay was put ashore on Penguin Island for a few days and then returned to their station; mail was delivered by air to all the northern FIDS stations; and various end of season movements of personnel were completed. *Protector* returned to Port Stanley on the 25th.

She left for the United Kingdom on 28 March.

Activities at FIDS stations, 1959

Routine meteorological observations were continued throughout the year at the occupied stations at Signy Island, Deception Island, Admiralty Bay, Hope Bay, Argentine Islands, Horseshoe Islands and Halley Bay. View Point in Duse Bay was occupied continuously by Hope Bay personnel who also made meteorological observations at this satellite station. Ionospheric work was carried out at Port Lockroy. Radio-sonde ascents and extensive programmes of geophysical observations were continued at the Argentine Islands and Halley Bay. At the latter the whole scientific programme initiated during the International Geophysical Year was continued with the exception of the ionospheric work and radio echo work which had to be abandoned because of lack of staff. Routine weather forecasts were made at Grytviken.

Regular sea ice observations were made at all the occupied stations.

Operating from Admiralty Bay, J. S. Bibby and G. J. Hobbs continued geological mapping and collecting at a number of localities on King George Island. During the early part of the year the triangulation on King George Island was carried through to Nelson Island in order to provide a survey link with the previous year's work on Livingston, Greenwich and Robert Islands. This was almost completed when it was abandoned because the tellurometer link was successful. Glaciological work was carried out on Stenhouse and Noble Glaciers, particularly measurement of movement.

On 23 April A. Sharman slipped and fell on ice-covered rocks at Admiralty Bay, and died as a result of this accident. On 26 July D. R. Bell, also of the Admiralty Bay station, lost his life in a crevasse.

Throughout the year work continued from the Hope Bay station on the triangulation of Trinity Peninsula in order to provide reliable ground control for the plotting of air photographs. A magnetometer survey of Tabarin Peninsula and northern Prince Gustav Channel was carried out. Geological work was continued in the Prince Gustav Channel area and on James Ross Island.

Geological work in Neny Fjord and on Millerand Island was carried out from the Horseshoe Island station. On 14 June a husky reached this station, having escaped during the evacuation of Detaille Island on 31 March. After travelling nearly 100 miles alone, he was in good condition and weighed 95 lb.

Appendix. *Wintering parties at FIDS stations*, 1959

Port Lockroy, Wiencke Island, Palmer Archipelago (Base A)

H. A. D. Cameron, Officer-in-charge and scientific assistant
M. A. Crockford, Radio operator mechanic
P. H. Leek, Scientific assistant
A. G. Lewis, Scientific assistant
D. M. Price, Diesel electric mechanic

Deception Island, South Shetland Islands (Base B)

P. J. Hodkinson, Officer-in-charge and meteorological assistant
I. T. Jackson, Senior meteorologist
E. B. Jones, Radio operator mechanic
M. D. Kershaw, Diesel electric mechanic
P. R. Rowe, Radio operator mechanic
P. L. Woodall, Meteorological assistant

Hope Bay, Trinity Peninsula (Base D)

D. McCalman, Officer-in-charge and assistant surveyor
K. Allen, General assistant/mountaineer
J. Ashley, Geophysicist
J. S. Bibby, Geologist
C. G. Brading, Assistant surveyor
J. Cheek, Radio operator mechanic
E. C. J. Clapp, Radio operator mechanic
A. Gill, Meteorological assistant
I. F. G. Hampton, Physiologist
T. A. Hanson, Assistant surveyor
R. M. Koerner, Senior meteorologist
L. Maloney, Meteorological assistant
C. A. Murray, Surveyor
N. W. M. Orr, Medical officer
M. D. Rhodes, Meteorological assistant
T. H. H. Richardson, Meteorological assistant
C. D. Souter, Diesel electric mechanic
R. Tindal, General assistant/mountaineer
J. D. J. Wildridge, Meteorological assistant

Argentine Islands, Graham Coast (Base F)

K. R. Bell, Officer-in-charge and diesel electric mechanic
H. E. Agger, Assistant scientific officer
A. Cumming, Medical officer
B. D. Giles, Senior meteorologist
C. N. Horton, Scientific officer
J. M. Nantes, Meteorological assistant
C. W. Pearson, General assistant/cook
A. Piggott, Radio operator mechanic
G. J. Roe, Meteorological assistant
J. B. Shaw, Meteorological assistant
C. M. Smith, Meteorological assistant

Admiralty Bay, King George Island, South Shetland Islands (Base G)

M. J. Stansbury, Officer-in-charge and glaciologist
C. M. Barton, Geologist
D. R. Bell, Meteorological assistant
K. V. Gibson, Meteorological assistant
J. C. A. Stokes, Assistant surveyor
R. D. Thompson, Senior meteorologist
E. Watson, Diesel electric mechanic
B. C. Williamson, Radio operator mechanic
J. M. Wilson, Diesel electric mechanic

Signy Island, South Orkney Islands (*Base H*)

J. W. Stammers, Officer-in-charge and meteorological assistant
R. B. Harrison, Meteorological assistant
K. Kenyon, General assistant
C. F. Le Feuvre, Radio operator mechanic
W. Mitchell, Diesel electric mechanic
F. O'Gorman, Biologist
R. Pinder, Radio operator mechanic
G. F. C. White, Diesel electric mechanic
J. W. Young, Meteorological assistant

Horseshoe Island, Fallières Coast (*Base Y*)

R. M. Perry, Officer-in-charge and senior meteorologist
J. L. Franks, Senior meteorologist
A. K. Hoskins, Geologist
J. M. Hunt, Meteorological assistant
J. F. Malden, Diesel electric mechanic
G. D. Mallinson, Radio operator mechanic

Halley Bay, Caird Coast, Coats Land (*Base Z*)

G. R. Lush, Officer-in-charge
G. M. Artz, Meteorologist
M. J. Blackwell, Scientific officer
J. Bothma, Meteorological assistant
N. A. Hedderley, Senior meteorologist (radio-sonde)
D. W. S. Limbert, Senior meteorologist (synoptic)
C. J. Mace, Cook
J. N. Norman, Medical officer
D. R. Savins, Radio operator mechanic
M. A. Sheret, Physicist
J. A. Smith, Meteorological assistant
W. Whitehall, Diesel electric mechanic

Grytviken, South Georgia (*Base M*)

D. Borland, Forecaster-in-charge
J. Cochrane, Meteorological assistant (until June)
J. Ford, Senior meteorological assistant (until June)
A. Freer, Meteorological assistant (until March)
D. O'Regan, Meteorological assistant (from September)
M. J. Reade, Meteorological assistant (from September)
P. A. Richards, Senior meteorological assistant (from June)

GEOPHYSICAL SURVEY IN THE FALKLAND ISLANDS DEPENDENCIES, 1959–60

[By D. H. Griffiths, Geology Department, University of Birmingham.]

South Georgia, the South Sandwich, the South Orkney and South Shetland Islands together with Graham Land appear to constitute an "island arc". Such arcs are thought to arise as a result of compressive stress in the crust along major fault planes, but their mode of origin is as yet uncertain and little is known about their geological structure at depth. It was with the intention of obtaining information about the geological structure of the arc that geophysical survey work was started in the Falkland Islands Dependencies during the summer season of 1959–60.

The survey was made possible through the generous co-operation of the Falkland Islands Dependencies Survey who made RRS *Shackleton* and RRS *John Biscoe* available for the work at various periods during the summer. Both magnetic and gravity measurements were made. A continuously recording proton magnetometer towed behind the *Shackleton* was used for the former, the gravity data being obtained with a Worden gravimeter by making landings at intervals on the coast or on offshore islands.

Only a limited amount of *Shackleton*'s time could be used for the magnetic survey since she had also relief work and hydrographic surveying to do. Of the available time a part was lost through instrument breakdown in the early stages and the survey was thus somewhat curtailed, being limited to the Bransfield Strait and the region north of the South Shetland Islands. The ship was fitted with a deep echo sounder; magnetic recordings and the complementary depth soundings being taken continuously. When within sight of shore the ship's position was fixed by radar or horizontal sextant angles. Out at sea navigation was by means of star sights and dead reckoning. The survey was therefore in the nature of a reconnaissance, but a useful amount of information was obtained, together with much invaluable experience. A proper assessment of the data has still to be made and until much more work has been done any conclusions are likely to be tentative. An interesting feature of the survey is the absence of any very marked anomaly over the foredeep to the north of the South Shetland Islands. It is over the foredeep in other island arcs that the major gravity disturbance is observed, though it is also true in these regions, where magnetic measurements have been made, that the gravity anomalies are not associated with clearly defined features in the magnetic field.

The aims of the gravity survey were to link the Falkland Islands Dependencies with the world gravity network through a well-established station at Buenos Aires, to establish a number of base stations in the Antarctic, and to do as much general reconnaissance as was possible in the time with the facilities available.

A link was first established by air between Buenos Aires and Montevideo, and a connexion made to the Falkland Islands Dependencies through the Falkland Islands during the outward and return journeys. Base stations were put in at clearly identified localities in South Georgia, at Deception Island, Admiralty Bay, Hope Bay, Port Lockroy and the Argentine Islands. Secondary stations were measured at between 10- and 20-mile intervals on the north side of the South Shetland Islands, on both shores of Bransfield Strait, and south through Gerlache Strait to the Argentine Islands. This station density proved to be sufficient to enable approximate gravity contours to be drawn. In general the contours follow the grain of the country, there being a steady increase in anomaly from south-east to north-west in the Bransfield Strait region.

Preparations are now being made to continue, and considerably extend, the work during the 1960–61 season. The gravity survey is likely to be concentrated in the region of the South Orkney and South Shetland Islands and the westerly fringe of Graham Land. It is hoped that it may be possible with the sea-borne magnetometer to concentrate on a few areas likely to be of particular interest, for example, the South Sandwich Islands and the Meteor Deep.

AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITION, 1959–60

[By P. G. Law. Previous accounts of these expeditions were published in the *Polar Record*, Vol. 10, No. 64, 1960, p. 55–58, and previous issues.]

The year 1959 was one full of incident and the ANARE suffered some severe setbacks. However, all difficulties were successfully surmounted and the stations are working smoothly again in 1960.

During 1959 Mawson station was manned by a party of twenty-three men led by John Bechervaise. The year was notable for the inauguration of flying operations from the plateau. Two ice runways were established: one about a mile south of the station, immediately above the steep coastal ice slopes, and the other at Mount

Twintop, the most southerly peak of the David Range. The RAAF Antarctic Flight during the year carried out reconnaissance and mapping flights (totalling 350 hours) over a wide area, and the surveyor obtained many new astro-fixes. Air operations ceased on 28 December, when the two Beaver aircraft were torn from their moorings and destroyed by a hurricane whose force exceeded 130 knots.

Intensive biological work was done on Emperor Penguins, involving dog-sledging over a wide area to reach rookeries at Fold Island, Auster Rookery and Taylor Glacier. Detailed surface surveying was done in connexion with small islands adjacent to Mawson.

A major fire destroyed the new power house at the station on 3 April 1960, but emergency facilities and some skilful improvisation enabled the scientific programme to be maintained throughout the remainder of the year. A fire also burnt down an auroral observatory containing valuable scientific equipment and records at the satellite station at Taylor Glacier, 50 miles west of Mawson. In both fires it was fortunate that men were not injured. Work at Mawson in meteorology, cosmic rays, geomagnetism, aurora, ionospherics, seismology, physiology and fauna studies continued satisfactorily.

On 4 February 1959, Australia took over administrative responsibility for the United States station at "Wilkes". Australian and United States scientists continued the programme previously carried out during the IGY by the United States alone, which includes meteorology, geomagnetism, ionospheric and auroral studies, seismology, zoology and glaciology. A satellite station, "S2", established by United States personnel in 1957, 50 miles inland on the plateau, was occupied intermittently for glaciological and meteorological observations.

In December 1959, a United States aircraft flew from "NAF McMurdo" to "Wilkes" to pick up, and take to New Zealand, an ANARE man who had suffered a breakdown in health. The plane landed on skis on the plateau névé about eight miles from the station.

Davis station was enlarged to permit the inclusion in the meteorological programme of upper air observations by radiosonde and rawinsonde. An interesting investigation of the major lakes of the Vestfold Hills was also carried out.

At Macquarie Island the year 1959 started with a very extensive programme of research in geophysics and biology, including auroral radar observations from Hurd Point at the southern end of the island. Unfortunately, early in the year a fire destroyed the physics laboratory at the main station with all equipment and records. A physicist was able to reconstruct an all-sky camera for auroral observations, but auroral parallactic height determinations and work in cosmic rays, whistlers, ionospheric soundings and ozone had to be abandoned. The geomagnetic, seismic and meteorological programmes were not affected.

ANARE relief voyages, 1960

Macquarie Island. Thala Dan (Captain H. C. Petersen) left Melbourne on 17 December 1959 with a relief expedition led by Richard Thompson. Macquarie Island was reached on the 21st and unloading operations lasted six days. A new kitchen was built. Four women biologists carried out work in littoral ecology, the effects of nesting sea-birds on plants, and the ANARE bird and seal programme. Auroral radar equipment was consolidated at Hurd Point; a United States radio-physicist made a survey for a site for measurements of low-frequency radio astronomy observations; ultra-low-frequency radio equipment and a new all-sky auroral camera were installed. Two Queen's Scouts accompanied the relief expedition. Leaving Macquarie Island on 27 December *Thala Dan* arrived at Melbourne on 1 January 1960.

ANARE helicopter crash-landed at southern extremity of Vincennes Bay, Wilkes Land, with rescue helicopter on a rocky peninsula in foreground

ANARE photograph by Phillip Law

(*Facing p.* 398)

Davis Island, Australian Antarctic Territory; *Magga Dan* in background

(ANARE photograph by Phillip Law

The 1960 wintering party at Macquarie Island comprised:

M. C. Taylor, Officer-in-charge
J. D. Atkinson, Carpenter
B. Brennan, Cook
F. Coleman, Senior weather observer
I. Ferguson, Weather observer (radio)
J. Goodricke, Weather observer
R. G. Levick, Senior technician (radio)
J. McQueen, Weather observer
C. V. Morgan, Diesel mechanic
Dr G. Palmai, Medical officer
M. Simon, Radio officer
I. N. Thomas, Radio officer
C. Van Erkelens, Geophysicist
J. Warham, Technical officer (biology)
H. L. Wright, Radio supervisor

Mawson. This expedition, led by Donald Styles, sailed from Melbourne on 10 January 1960 in *Thala Dan.* The ship carried on deck a Dakota aircraft with wings removed. Physicists on board operated a freezing nucleus counter for the rain study group of CSIRO.

Arriving at Mawson on 25 January, all efforts were directed to the safe unloading of the Dakota which proved to be a major problem. This was successfully achieved, and 760 tons of general cargo were also unloaded. On 1 February the Director, Phillip Law, flew to Mawson by Beaver from Davis to inspect the station and to discuss future aircraft operations from the plateau runways, rejoining *Magga Dan* on the 5th.

The major construction job at Mawson was the building of the new power house and workshop to replace that destroyed by fire. Other construction included a new garage for weasels and tractors, an auroral laboratory, a radio transmitter hut, a refrigerator room, a heated store hut, and additional sleeping accommodation.

The 1960 wintering party left at Mawson comprised:

H. Geysen, Officer-in-charge
K. L. Bennett, Radio officer
I. G. Bird, Engineer (electronics)
G. Cresswell, Physicist
G. Currie, Radio supervisor
N. J. Collins, Senior diesel mechanic
W. Dick, Weather observer
R. Dyer, Cook
T. J. Elkins, Physicist
V. Hill, Radio officer
J. Humble, Physicist
N. D. Jennings, Assistant diesel mechanic
W. Kellas, Weather observer
S. L. Kirkby, Surveyor
D. Machin, Radio officer
W. R. Merrick, Geophysicist
H. Munstermann, Weather observer (radio)
Dr G. Newton, Medical officer
R. A. Ruker, Geologist
N. A. Streten, Meteorologist
O. Zakharoff, Radio officer

Members of the RAAF Antarctic Flight were:

Sq.Ldr. J. Kichenside, Commanding officer
F/O. K. Assender, Pilot
F/Lt. E. Bloomfield, Navigator
F/O. G. Dyke, Pilot
and 8 technicians

Thala Dan left Mawson on 16 February and the following day pushed in through heavy pack ice to make the first landing on the coast in the King Edward VIII Gulf area. Here investigations of an Emperor Penguin rookery at Kloa Point were made, and stores were taken ashore across fast ice by a man-hauled sledge to establish a depot on a rocky dump 2 miles south of Kloa Point, for use by a survey party at a later date. The ship then sailed westwards around Enderby Land to the vicinity of Proclamation Island, where a survey party of three men with two dog teams and sledges were landed on 22 February. They sledged across Enderby Land to the depot near Kloa Point where, on 20 April, they were picked up by aircraft and flown to Mawson.

Thala Dan continued south-westward and sailed into Casey Bay, confirming the position and extent of White Island on the way. Leaving Antarctica on 29 February, *Thala Dan* returned to Melbourne via Heard Island and Iles Kerguelen, arriving on 19 March.

"*Wilkes*", *Davis and Lewis Island. Magga Dan* (Captain Harald Pedersen) was used for this relief expedition, which was led by Phillip Law. Leaving Melbourne

on 5 January 1960, the ship had a smooth run south and attempted to approach Oates Land, but the ice in the vicinity of Virik Bank was too heavy to penetrate, so course was set for "Dumont d'Urville", where a courtesy call was made at the French station on 14 January.

ANARE used helicopters for the first time in Antarctica during this voyage, two Hiller aircraft chartered from Trans Australia Airlines being carried. A Beaver aircraft was also taken. A photographic run of the coast east of "Dumont d'Urville" was carried out on 15 January using the Beaver, which flew as far as Mertz Glacier Tongue. The ship departed the same evening for Lewis Island.

Anchoring off Lewis Island on the 17th the expedition made the most of a two-day stay. The automatic weather station was overhauled, the magnetic station was re-occupied, and a census of the birds of the island was made.

On 18 January the two helicopters took a survey party to establish an astro-fix near Glacier Français in Adélie Land, while the Beaver aircraft carried out a photographic run for 100 miles to the east of Lewis Island. A launch party explored Dibble Iceberg Tongue and landed on Anton Island. The ship departed on 19 January for Davis, making an unsuccessful attempt to approach Cape Goodenough on the way.

Magga Dan arrived at Davis on 30 January and unloaded 50 tons of stores. A new surgery was built and a new method of heating the huts, using hot water from a heat exchanger working off the diesel generator exhausts, was installed.

On 31 January the helicopters landed a survey party on the Rauer Group while the Beaver obtained aerial photo-mosaics of the Larsemann Hills, Svenner Isle and Rauer Group. On 1 February the Beaver flew Law to Mawson.

Magga Dan left Davis on 3 February and sailed towards Mawson. On 4 February the illness of a member of the 1959 Mawson party was diagnosed as poliomyelitis. On 5 February, Law flew out to rejoin *Magga Dan* which then set sail for "Wilkes". The Beaver returned to Mawson to remain for the rest of the year.

The wintering party left at Davis for 1960 comprised:

Ian Douglas, Officer-in-charge
N. R. Barratt, Weather observer
L. N. Fox, Weather observer
D. Hobby, Diesel mechanic
J. D. Molle, Radio officer
K. C. Oldroyd, Weather observer (radio)
M. T. K. Power, Radio supervisor
W. Suter, Cook

Arriving at "Wilkes" on 11 February, the ship immediately started unloading. During its 8-day stay a new transmitter hut was built and new rhombic aerials erected; 400 tons of cargo were unloaded; the helicopters carried a geologist and a biologist to a number of inaccessible islands; and a weasel visit was made to "S2" station.

An unlucky accident resulted in the loss of one helicopter (fortunately with only minor injuries to its crew) when the two machines were attempting to approach Hatch Islands at the bottom of Vincennes Bay, where a strong katabatic wind was blowing. Both helicopters were forced to land by powerful down-draughts and one crashed on the continental ice only twenty yards from the high coastal cliffs. *Magga Dan* rescued the men and the undamaged aircraft.

The wintering party left at "Wilkes" for 1960 comprised:

H. P. Black, Officer-in-charge
G. E. L. Burkett, Radio officer
R. W. Butling, Plumber
S. M. Campbell, Radio supervisor
T. A. Edwards, Assistant diesel mechanic
N. Graham, Cook
J. R. Harrop, Weather observer
R. Honkala,* Meteorologist
W. K. Jones, Geophysicist
W. H. Lensink, Weather observer
J. Lunde, Senior diesel mechanic
R. Penney,* Biologist
J. C. Smith, Mechanic
Dr F. Soucek, Medical officer
A. F. Spano,* Weather observer
B. A. Wall, Physicist (ionosphere)
D. J. Ward, Radio officer
D. L. Yingling,* Weather technician

* United States personnel.

On 19 February the ship left "Wilkes" and sailed south; new landings were made on a small peninsula west of Hatch Islands, and on the largest of the Davis Islands. Astro-fixes were obtained, also geological, magnetic and biological data and aerial photographs.

The *Magga Dan* sailed on 20 February for Cape Southard, reaching "Chick Island" without great difficulty on the 23rd. Landings were made and scientific observations were carried out at "Chick Island", and at the Henry Islands, about 12 miles further west. Delayed by bad weather the ship did not depart until 25 February. An iceberg tongue extending for about 60 miles north from Cape Southard was followed and plotted, and a course was then set for Lewis Island which was reached on 28 February, and final adjustments were made to the automatic weather station. The ship sailed on 29 February for Melbourne via Macquarie Island, arriving on 11 March.

TUFTS COLLEGE–NATIONAL SCIENCE FOUNDATION ANTARCTIC EXPEDITION, 1959–60

[Summarized from information provided by R. L. Nichols, Tufts University.]

During the summer of 1959–60, a party from Tufts University and Hamline University, under the leadership of R. Nichols, studied raised beaches on the west coast of McMurdo Sound, between Granite Harbour and New Harbour, also the geomorphology of the 6 miles of the Wright Glacier Dry Valley nearest to the Wilson Piedmont Glacier.

From a base camp at Marble Point the party manhauled equipment over the sea ice to sites on Dunlop Island and at Cape Roberts, to which supplies had been carried previously by United States Naval helicopter.

A large number of well-developed elevated beaches were observed, the highest being 67 ft. (20 m.) above sea level; this was at Dunlop Island. The beaches were derived mainly from till and outwash, and some were buried by solifluction, eolian, outwash and landslide deposits, also by talus. An extensive elevated beach at Marble Point was 45 to 55 ft. (14 to 16 m.) above sea level. The beach gravels were in places 15 to 20 in. (38 to 50 mm.) thick and rested on clean ice, which, at one place, was 7 ft. (2 m.) thick. This is believed to be an elevated ice foot, and not a stagnant mass of glacial ice.

Numerous pits and hollows, round, oblong or irregularly shaped, were found in many of the beaches, ranging in diameter from less than 15 ft. (5 m.) to more than 40 ft. (12 m.), and generally less than 4 ft. (1 m.) deep. They were formed by the differential melting of the ice on which the beaches had been deposited. The presence of pits, gaps in beach ridges, abrupt truncation of beach ridges, and the occasional absence of the highest beach ridge prove that the highest and oldest were formed close to glacier ice. All the elevated beaches were formed in climates similar to that now found in the McMurdo Sound area. A radio-carbon analysis of an Elephant Seal buried in an elevated beach about 44 ft. above sea level at Marble Point indicated a date of about 4600 ± 200 years for this beach. The highest and oldest beaches are therefore probably some 6000 years old.

Wave-washed bedrock surfaces, and marine boulder pavements were also common.

The marine limit at Marble Point was 66 ft. above sea level, and the same at Cape Roberts, about 30 miles north. There is, therefore, no tilt of the marine level between these two points.

Evidence of multiple glaciation was found in the Wright Glacier Dry Valley.

VISIT TO ILES CROZET AND ILES KERGUELEN, 1959–60

[Summarized from an account by H. W. Tilman.]

H. W. Tilman and a party of five visited Ile Crozet and Iles Kerguelen during the southern summer of 1959–60. They sailed in *Mischief* an ex-Bristol cutter of some 30 tons, powered by a Chrysler petrol engine, with a range of about 300 miles.

The party left Cape Town on 3 December, passed Marion Island on the 20th, hove to off Ile des Pingouins on the 27th, to anchor in Baie du Navire, Ile de la Possession, the same evening. Fifteen days were spent on the island during which the three main peaks were climbed and found (by aneroid) to be 3150 ft. (960 m.), 3100 ft. (943 m.) and 2700 ft. (823 m.). A botanical collection was also made, and some 200 Albatrosses and Giant Petrels ringed. A large King Penguin rookery was seen at Baie du Navire, and several others between there and Baie Americaine.

The party left Iles Crozet on 10 January 1960, sailing close along the south shore of Ile de l'Est, and sighted Cap d'Estaing, on Iles Kerguelen, a week later. They anchored for the night at Port Fuller and then, failing to sight the entrance to Baie Cachée, reached Port d'Hiver and anchored there.

Tilman and one other discovered a way up on to the glacier which drains into Baie Irlandaise, and spent 10 days crossing the ice cap and on for about 4 miles on the west side. They estimated that the ice cap was about 25 miles (40 km.) long and 8 miles (12 km.) wide, and noted a large number of glaciers flowing from it.

On 27 January they sailed on to Port aux Français and left for Cape Town on 2 February, arriving there on 14 March.

NEW ZEALAND ALPINE CLUB EXPEDITION TO THE ROSS DEPENDENCY, 1959–60

[By R. L. Oliver, Geology Department, Adelaide University, Australia.]

Eight members of the New Zealand Alpine Club spent six weeks during the 1959–60 summer manhauling in the unexplored area immediately east of the mouth of the Beardmore Glacier, Ross Dependency. They were R. W. Cawley (leader), C. H. Tyndale Biscoe (deputy leader and biologist), M. R. Bolt (surveyor), N. C. Cooper (assistant surveyor), R. L. Oliver (geologist), P. L. M. Bain, B. J. McGlinchy and B. L. Smith.

The party was flown from New Zealand to McMurdo Sound and on to a United States three-man weather station on Ross Ice Shelf, 30 miles from the coast, by United States aircraft. A base depot was established on 30 November in lat. 83° 47′ S., long. 173° 25′ E., near the mouth of "Hood Glacier" 15 miles east of the foot of the Beardmore Glacier. The "Hood Glacier" as depicted in this vicinity by Shackleton does not seem to exist.

The party spent two weeks exploring and surveying west of the base depot, as far as a small glacier debouching on to Ross Ice Shelf immediately east of the mouth of the Beardmore Glacier, and separated from it by Mount Kyffin (5130 ft.). This glacier, together with Mounts Robert Scott (4890 ft.), Vernon Harcourt (4500 ft. approx.), an unnamed peak (4500 ft. approx.) and several ridges and spurs were traversed.

On return to base, the expedition divided into two. Four members went up "Hood Glacier" to about 5500 ft., climbing two peaks, one of which is believed to be Mount Patrick (7330 ft.) and reaching a peak about 25 miles from its foot. From Mount Patrick there were good views to the east over a large glacier and to

From the ridge above Baie Americaine, Ile de la Possession, showing Sir James Clark Ross' "Red Cliff", and Ile de l'Est in background

South-west coast of Ile de la Possession from one of the two highest peaks

Photographs by H. W. Tilman

(*Facing p.* 402)

The beach at Baie du Navire, Ile de la Possession, looking towards Ile de l'Est. *Mischief* in background

Looking north along the ridge of Ile de la Possession from one of the two highest peaks (about 3,100 ft.)

impressive peaks beyond. At the head of "Hood Glacier", bad weather set in which lasted for 8 days and prevented any further travel or survey work from this vantage point. Wedge Face, bordering the Beardmore Glacier, was climbed on the return.

The lower glacier party climbed Mount Kathleen (4500 ft. approx.), on the west side of the mouth of "Hood Glacier", before establishing a survey base line 8 miles south at the foot of a spur which juts into the east side of "Hood Glacier". Survey work on the ridge above involved climbing a 3700 ft. peak.

Exploration of the west side of "Hood Glacier", including an ascent of Mount Cyril (4500 ft. approx.), disclosed a low pass communicating with the Beardmore Glacier, and accessible by both vehicles and dogs. This is possibly the best route for future ground parties travelling up the Beardmore Glacier as it avoids the heavily crevassed area at its foot.

Bad weather curtailed activities after 25 December until, on 5 January 1960, after a laborious retreat to 1 mile north of the base depot, a survey point was established to tie in the coastline.

The parties were reunited on 6 January and returned to Scott Base by the RNZAF Antarctic Flight.

The topographical survey, which included eight stations fixed by sun sights, will result in a map covering some 1200 sq. miles. A sketch map of the area has already been prepared.

The collection of two species of Collembola new to the Antarctic, and other insects, is believed to be the furthest south recorded occurrence of indigenous animal life. Specimens of lichens, mosses and algae were also collected.

Metagreywackes (Ross System) and intrusive granodiorites (Admiralty Intrusives) were the main rock types encountered. Very similar rocks were collected during the 1959–60 summer, in the region north of the Beardmore Glacier,[1] and the continuity of the Ross System metagreywackes from Victoria Land southward, at least as far as the east side of the Beardmore Glacier, seems established.

[1] *Polar Record*, Vol. 10, No. 66, 1960, p. 280.

NOTES

REINDEER HUSBANDRY IN THE SOVIET ARCTIC, 1958

[Based on *Poronhoito suomensukuisten kansojen keskuudessa* by Yrjö Alaruikka (Rovaniemi, 1959). Mr Alaruikka, who is concerned with the administration of the Finnish reindeer industry, paid a 5-week visit to Soviet reindeer-breeding areas during September–October 1958, accompanied by an interpreter. A full English translation of his report, commissioned jointly by the Scott Polar Research Institute and the Reindeer Council of the United Kingdom, is available at the Institute.]

Introduction. The areas visited were in Komi ASSR and Nenetskiy Natsional'nyy Okrug (the national district of the Nentsy, or Samoyed). The terrain in both regions consist of tundra underlain by permafrost, the tundra having been formed by a layer of peat-moss, often 4 m. thick, growing over the permafrost and, in turn, becoming covered with lichens. Although lying between lats. 66° and 68° N. the summer warmth has little effect on the permafrost underneath its layer of peat-moss and the Finn appreciated the effect which the Gulf Stream has on the climate of his country. The tundra is cut by numerous shallow watercourses, the result of frost action on the peat-moss; these are widened by water flowing during the summer months and finally amalgamate to form large rivers such as the Ob' and Pechora.

The country is flat and monotonous, the only landmarks being iron-framed survey towers, set up at intervals of 10 km.

The flora consists of a narrow range of species. Willow thickets are found on river banks, lake shores and swampy areas: they include *Salix polaris*, *S. herbacea*, *S. reticulata* and *S. glauca*. The brushwood vegetation consists mainly of wild rosemary (*Ledum palustre*), *Phyllodoce coerulea*, *Loiseleuria procumbens*, and a few other species. Among the lichens found are *Cladonia rangiferina* in wooded areas and *Cl. alpestris* and *Cl. sylvatica* in the tundra. On the lake shores and watercourses there is sedge grass, *Carex microglochin*, *C. rupestris*, *C. lachenalii*, *C. rigida*, *C. atrata*, *C. pedata*, *C. saxatilis* and *C. rotundata*. There are also large areas of *Colpodium fulvum* growing in the shallow lakes and used as pasture for the reindeer in October.

Grazing. Controlled grazing is practised in both areas. The ranges, running from north to south, are about 300 to 350 km. long and 15 km. wide. They are divided into seasonal sections, and an annual rotation is closely followed, with the animals grazing in the north in summer and moving south in winter. Herds are kept as widely spread out as possible within the boundaries to minimize damage to lichen underfoot; a herding density is aimed at of 30 to 35 sq. km. per animal. Herdsmen are fined if their animals stray beyond the boundaries of the grazing grounds.

Table 1 shows the organization of grazing grounds for a herd of 3,500 head of reindeer in Nenetskiy Natsional'nyy Okrug. The figures in Column 4 represent the number of days during the year in which an animal can feed on lichen in an area of 1 hectare; column 5 gives the corresponding figure for green fodder (grass and leaves). When one of these figures is multiplied by

the number of hectares in the area, the result is the total number of pasturing days in that area.

Reindeer. The reindeer in both areas visited were larger than the type most common in Lapland, though small numbers of the Russian type are found in Muddusjärvi, Inari, and in Lohijärvi. The average live weight of a $2\frac{1}{2}$-year-old cow in the USSR is 100 kg., and in Finland it is 75 kg. A calf, born on 27 May at the breeding station at Nar'yan Mar, weighed 6·6 kg. and by 2 September had increased to 60 kg. The corresponding weights in Finnish Lapland would have been 5 and 36 kg. The greater increase in growth is due both to the larger milk production of the cows and to the confined feeding pastures which do away with the necessity for long journeys in search of food. The Russian reindeer are strong and powerful with wide shoulders and haunches and carry a large weight of meat. The commonest colour is a charcoal grey.

Table 1. *A reindeer grazing ground in Nenetskiy Natsional'nyy Okrug*

Vegetation of terrain	Area in hectares	Size of actual pastures	Lichen fodder days	Green fodder days
1	2	3	4	5
Tundra, dwarf birches	401	297	—	9·4
Moss, tundra pasture	415	404	—	12·5
Lichen swamp, brushwood	590	589	17·3	—
Lichen tundra	619	611	25·0	—

Considerable attention is paid to stock improvement and breeding stations are maintained in which all branches of reindeer husbandry are studied. In addition to these stations, reindeer herds are owned by state and collective farms. Total figures for domestic reindeer in the USSR are:

1954	2,152,200
1956	1,987,600
1957	2,062,700
1958	1,907,300

The low figure for 1958 was due to an unusually severe winter and a particularly large number of animals being slaughtered.[1] The ownership of these animals is divided between 40 state farms owning 300,000 head, 640 collective farms owning 1,500,000, and about 250,000 in private ownership. The largest private herd consists of 170 animals.

Table 2 shows the distribution (in thousands on 1 January 1958) in the various areas and types of country. The wooded tundra regions are apparently the most suitable for reindeer, carrying 65·8 per cent of the total herds. The annual meat production, per 100 animals, varies between 2100 and 4000 kg., the latter a record in an area where the average live weight was 240 kg. In Finnish Lapland the corresponding weights would be 1500 to 2000 kg. Dead

[1] *Pravda* of 11 February 1960 reported that "in the last six years about $1\frac{1}{2}$ million reindeer in the collective farms died, were killed by predators and were lost without trace". This was ascribed to the fact that "inadequate measures were taken to raise the herder's material interest in the herd, to improve the material and technical basis of reindeer husbandry, and to rationalize use of pastures".—*Ed.*

weight, excluding head and hooves, is calculated at 50 to 55 per cent of the live weight.

Calving. As the calving season approaches, the herds are driven towards areas in which the spring sun has thawed as much of the snow as possible, such as mountain ridges similar to those Finnish ridges north of Palojärvi in

Table 2. *Number of reindeer, in thousands, in northern regions of USSR, January* 1958

	Tundra		Wooded tundra		Forest region		Total	
	Head	%	Head	%	Head	%	Head	%
North Europe and West Siberia	19·8	—	728·6	—	38·2	—	786·6	41·3
East Siberia	181·9	—	203·9	—	63·0	—	448·8	23·5
Far East	283·3	—	321·8	—	66·9	—	671·9	35·2
Total	485·0	25·4	1254·3	65·8	168·0	8·8	1907·3	100·0

Enontekiö, and in Kolsanharju in Salla. Snow melts early on these southern slopes and the calves are therefore not born on to the snow. Preservation rates[1] for the years 1953–57 in specimen areas are expressed in the following percentage figures:

	Calves (%)	Cows (%)
Chukotskiy Natsional'nyy Okrug [Chukchi national district]	71	89
Evenkiyskiy Natsional'nyy Okrug [Evenki, or Tungus, national district]	66	87
Taymyrskiy Natsional'nyy Okrug [Taymyr national district]	69	87
Poluostrov Yamal [Yamal peninsula]	76	96
Nenetskiy Natsional'nyy Okrug [Nentsy, or Samoyed, national district]	80	92
Murmanskaya Oblast' [Murmansk province]	75	93

In Taymyrskiy and Evenkiyskiy Natsional'nyy Okrug there are large numbers of wild reindeer which entice the tame animals away from the herds, making the survival rates in these two areas the lowest in the country.

Marking. Reindeer are marked by means of distinctive symbols cut in the outer ear to indicate herd and region origins. Pedigree animals have, in addition, small metal plates inserted in their ears indicating date of birth, stock book number and other details. Markings are made soon after the calf is born.

Herding. Two herdsmen, with dogs and draught reindeer, can look after 3500 animals in shifts, driving the draught reindeer during snow-free periods and otherwise using ski. The draught animals are trained to detach themselves from the herd in response to the herdsman's call.

There are five training centres for reindeer herdsmen in which 250 men take

[1] This appears to mean the proportion of live cows and calves remaining with the herds. Not all losses are necessarily deaths, as the last sentence of the paragraph makes clear. *Ed.*

part in a 5-year course covering all aspects of husbandry. A further 4-month course of advanced studies is provided at Leningrad University.

In practical charge of all activities concerning reindeer on state and collective farms is a "herd chief". These men receive a 4-year training in special schools and are responsible to the Director of a collective farm or the Chairman of the Committee of a State farm. The chain of responsibility then leads to the District Committee and the Executive Committee of the National District. The final authority is the reindeer breeding director of the central Soviet government.

Special attention is paid to housing for the herdsmen, and experiments have been carried out with prefabricated aluminium and hardwood huts. The huts seen on the tundra consisted of a skeleton of poles covered with canvas, reindeer skin or bark and had a diameter of about 8 m. They had wooden floors covered with skins and a central stove for cooking and heating. Two families occupied each hut.

Reindeer warbles. The Russians have had considerable success in controlling reindeer warbles, a pest which can reduce the weight of a grown animal by 6 kg. a year. One method is to spray a DDT solution above the herds when the insects are in flight; an effective method in the open tundra, but not in wooded country. A serum, immunizing the animal against the larvae, is also in use.

Meat canning. Animals for slaughter are selected in September and October and are those which do not conform to stock improvement standards, usually 25 to 33 per cent of a herd. They are culled at 6 months old which is considered the most economical age; at 6 months a calf yields 30 kg of meat, and a year later this yield only increases to about 40 kg. Another reason is that the bulk of weight is built up on the summer pastures which renew themselves much faster than the winter ones. At this age, too, the flesh is at its best for canning. The meat is canned in 350 g. tins containing about 10 per cent lard together with a seasoning of pepper, onions and bay leaves. The Finnish practice of including 10 to 15 per cent of pork as well is not followed. A factory visited on the Barents Sea coast was staffed by 200 women preparing the meat, three male cooks and one engineer. The installation was used for the remainder of the year to can fish. The total Soviet output of meat is 25,000,000 kg.,[1] more than twenty times that of Finland.

SUB-ARCTIC FIELD RESEARCH STATION IN FINNISH LAPLAND

[From a note by Professor P. Kallio.]

In 1958 a field research station was established by the University of Turku for the study of the natural history of the sub-Arctic and Arctic regions of Finland. This station, which is called Kevo, is located in Utsjoki, the northernmost commune of Finnish Lapland, and north of the continuous pine forest

[1] This figure does not accord with the meat production figures quoted on p. 405, neither is it consistent with the slaughtering of calves only, as implied earlier in the paragraph. *Ed.*

limit. It is situated on the banks of the Utsjoki river and surrounded by an isolated pine forest that is one of the northernmost in the world. This forest is encircled by groves of scrubby birch (*Betula tortuosa*), and the treeless "regio alpina" begins not far away, at about 300 m. above sea level. Near the station is the Kevo Natural Park, which has been reserved by law for research purposes and is widely known for the great variety of plant and animal species found there. This area of 346 sq. km. is one of the least disturbed in all Finland, and is admirably suited for research purposes.

At present the building at the station comprises a small laboratory with accommodation for six to eight persons during the summer season; an extension of the station to permit the establishment of a meteorological observatory is under consideration.

THE MAWSON INSTITUTE FOR ANTARCTIC RESEARCH

In November 1959 the University of Adelaide established the Mawson Institute for Antarctic Research within the Department of Geology, in honour of the late Professor Sir Douglas Mawson, F.R.S., the Australian explorer. Sir Douglas's association with the University of Adelaide was a long one; he became a lecturer in Geology and Mineralogy in 1905 and was appointed Professor in 1921; from 1931 until his death in 1958 he was a member of the University's governing body.

The broad aim of the Institute is to foster by various means Antarctic studies and research. It will maintain a library and a museum of geological and biological specimens. The museum will also include objects associated with the explorations of Sir Douglas Mawson. Rooms will be made available for the use of workers engaged in Antarctic research, and the Institute intends to arrange for suitable public lectures to be given from time to time in the University.

The Institute, with the approval of the Commonwealth Government of Australia, has undertaken to edit and distribute the remaining unpublished scientific reports of the BANZARE Expedition.

The chairman of the Committee of Management is Sir George Ligertwood, Deputy Chancellor of the University of Adelaide, and the secretary is Mrs Ifor Thomas.

FUR SEALS BREEDING IN THE SOUTH ORKNEY ISLANDS

[From an illustrated article by Torger Oritsland in *Norsk Hvalfangst-Tidende*, 49 Årg., Nr. 5, 1960, p. 220–25.]

Due to extensive and ruthless over-exploitation, the Fur Seals of the island groups of the Falkland Islands Dependencies were practically exterminated during the nineteenth century. During the past 20 years it has been encouraging to note increasing evidence of recovery of this species in the area.

In recent years Fur Seals have been sighted on all the main islands of the

South Orkney group, but until now there has been no undoubted proof of breeding since the days when the sealers cleared every beach.

On 6 December 1959 Torger Øritsland landed on Powell Island and Michelsen Island from the Norwegian whale catcher *Tromstrål II*. On Michelsen Island, near the narrow isthmus joining the two islands, a Fur Seal rookery was found, consisting of one bull and a cow with a very young pup. On the same day two other Fur Seals were seen close by. On 17 February 1960 it was possible to make another landing on Michelsen Island. The rookery then contained one bull and eleven cows with pups. Nearby, there were five adult bulls on the beach and a few more bulls were playing in the water. In the same area that had been examined on 6 December, 111 Fur Seals were counted. The majority were males, but unfortunately no record was made of the numbers of each sex.

It is to be hoped that these Fur Seals will constitute a foundation for a future Fur Seal population in the islands. Under proper protection and management, such a population could give rise to a new sealing industry in the islands at some time in the future.

NEW RECORD LOW TEMPERATURE IN ANTARCTICA

[Summarized from *Soviet News*, 26 August 1960.]

A new record low temperature of −88·3° C. (−158·9° F.) was established at the Soviet Antarctic station "Vostok" on 24 August 1960.

ICEBERG TONGUES

[Note by B. B. Roberts, Secretary of the United Kingdom Antarctic Place-names Committee.]

An illustrated note by P. G. Law in the *Polar Record*, Vol. 8, No. 55, 1957, p. 375–76, proposed the new term "iceberg tongue".

After consultations, this term has now been adopted for official use by the Advisory Committee on Antarctic Names of the United States Board on Geographic Names, the Antarctic Names Committee of Australia, the New Zealand Antarctic Place Names Committee and the United Kingdom Antarctic Place-names Committee.

The agreed definition is as follows:

"ICEBERG TONGUE

A major accumulation of icebergs projecting from the coast, held in place by grounding, joined together by fast ice, and extending at least 10 miles (16 km.) seawards."

NEW DANISH ICE-STRENGTHENED SHIPS

[From information supplied by J. Lauritzen Lines, København.]

J. Lauritzen Lines, København, have recently announced a fourth post-war programme of ship construction which includes five ice-strengthened ships

for polar service to be built in 1960–62. At present the company has a fleet of fourteen polar ships.

Three of these new ships will be of 3,700 tons deadweight, one of 2,300 tons deadweight and one of 2,100 tons deadweight. The first four will be of similar design (bridge aft) to the recent *Rimja Dan*, and they will be built by Bijker Werf and Werf de Noord, near Rotterdam.

A distinctive feature of the fifth ship, which is to be of the *Thala Dan* type (bridge amidships), is the provision of a fixed helicopter deck. This ship will therefore be especially suitable for use by polar expeditions with air reconnaissance and air support requirements. Accommodation will be provided for thirty-six passengers, and the ship is to be built at the Aalborg Shipyard, Denmark.

All five ships will serve the company's Baltic Sea trade as well as the Arctic and Antarctic.

SOVIET ICEBREAKER *MOSKVA*

[Summarized from information supplied by Wärtsilä-koncernen A/B, Helsinki.]

On 11 June 1960 Wärtsilä-koncernen A/B of Helsinki delivered to the USSR the first of two 22,000 shp icebreakers ordered in May 1956. This ship, *Moskva*, is now the largest conventionally powered icebreaker in the world. A sister ship, to be called *Leningrad*, is due for delivery in 1962, and both vessels are intended for service in polar regions north of Siberia.

Principal dimensions of the *Moskva* are: overall length 122·1 m. (400 ft.), moulded beam 24·5 m. (80 ft.), maximum draught 10·5 m. (34 ft.), three screws (all aft), speed 18·3 knots.

The hull has an extended forecastle reaching well abaft the front bulkhead and a heavy superstructure aft, which includes a helicopter hanger and landing deck. As the hull is fitted with wing tanks throughout, it is actually a double hull up to the tween deck, well above the water line. The capacity of double bottom, wing, peak and deep tanks is sufficient to store 3,200 tons of diesel oil, 290 tons of boiler fuel, 130 tons of lubricating oil, 320 tons of fresh water and 20 tons of aviation spirit. There are also spare tanks allowing a maximum bunker capacity of 5,300 tons.

Four heeling pumps are capable of transferring 480 tons of water from one side to the other in 120 sec., resulting in a heeling angle of about 14°.

The hull strength is in excess of both Lloyd's Register of Shipping Class 100 A1, strengthened for navigation in Ice Class 1, and the Finnish Ice Class 1A. The waterline plating can withstand a pressure of 1,000 tons per sq.m. forward, 600 tons per sq.m. amidships, and 800 tons per sq.m. aft (a corresponding figure for an unstrengthened vessel would be between 15 and 30 tons per sq.m.). The hull is completely welded, and the shell plating is constructed from special steel with high impact strength at low temperatures. Frame spacing is at 400 mm. (15·75 in.) intervals and the shell plating in the ice strake has a maximum thickness of 54 mm. (2·12 in.).

Eight Wärtsilä–Sulzer diesel generators feed DC current to four propelling

motors. Each motor develops 3250 bhp at 330 rpm, but can be overloaded by 10 per cent for one hour. The centre propelling motor consists of two motors in tandem, each developing 5,500 hp at 1,200 V. and 3,600 amp. The two wing motors also each develop 5,500 hp. The nominal rpm is 115 but full power can be obtained at all revolutions between 110 and 150. The operation of the propelling motors is directly controlled from the bridge.

Auxiliary power is supplied by seven diesel generators.

Steam required for heating, keeping cooling water intakes free from ice and for domestic purposes is supplied by two Wärtsilä–Babcock & Wilcox water tube boilers.

The steering gear is of the electric hydraulic type with four cylinders and two pumps, and is capable of moving the rudder from hard over to hard over in 20 sec. at full speed.

Two engine control positions are located on the upper bridge, three in the wheelhouse and one on the after bridge above the helicopter deck. A steering console in the wheelhouse incorporates an engine telegraph, gyro repeater and a rudder indicator. The vessel can also be steered from the upper bridge and the steering gear room.

The usual navigational aids are fitted.

The crew of 117 and research group of nine are accommodated in one- or two-berth cabins. Group accommodation is provided for a further 36 men.

CANADIAN ICEBREAKER, *CAMSELL*

[Summarized from *Shipbuilding and Shipping Record*, No. 94, 1959, p. 507–09.]

The twin-screw icebreaker *Camsell* was built for the Department of Transport of the Canadian Government by Yarrows Limited, Victoria, British Columbia, and entered service late in 1959. Besides her icebreaking duties, she will operate as a lighthouse supply and buoy ship. *Camsell* is the first vessel of her type to be built in western Canada for service off the Alaskan coast.

Dimensions are: length overall 223 ft. 6 in., moulded breadth 48 ft., moulded depth 21 ft., draught 16 ft., gross tonnage 2,022 tons. Radius of action at a cruising speed of 11 knots is 12,000 miles, and her maximum speed is 13·5 knots.

Designed in accordance with the same principles used in previous successful Canadian Government icebreakers, the ship is built in excess of Lloyd's classification 100 A1, icebreaker. Below decks the hull is subdivided into nine watertight compartments. The shell plating is 1 in. thick increasing to 1·25 in. at the stem. Frame spacing is generally at 16 in. intervals, and, with the exception of deck stringer angles, the hull is of all welded construction. Longitudinal stringers and web framing give additional strength to the hull. Forward and aft cargo holds have a capacity of 50,000 cu. ft., part of this space being refrigerated.

Four Canadian Fairbanks–Morse diesel engines drive four generators which supply power to two electric propulsion motors each capable of a continuous

output of 2,125 shp at 105 rpm when icebreaking. At the main switchboard, all outgoing circuits are controlled by both magnetic and thermal circuit breakers arranged so that, should an overload occur when icebreaking, any non-essential load will be disconnected prior to the generator circuit breaker tripping. The propellers have nickel vanadium steel blades, each of which is removable.

Remote control from four positions on the navigating bridge is provided for the engines. Navigational equipment includes radar, radio direction-finding apparatus, gyro compass and echo sounder. A helicopter platform is provided aft.

CORRESPONDENCE

ARCTIC INSTITUTE OF NORTH AMERICA: APPLICATIONS FOR RESEARCH SCHOLARSHIPS

I am pleased to write that the Arctic Institute is inviting applications from research scientists interested in Arctic and sub-Arctic North America and in Antarctica. The aims of the institute's grant-in-aid programme, which last year numbered thirty-five awards ranging in value from $400 to $10,000, are to support the work of experienced field scientists, and to introduce other competent researchers to polar science. The institute favours no particular scientific disciplines, but appraises proposals on the basis of their individual excellence. Grants are usually made for a one-year period.

Opportunities for field research in Arctic Alaska and Canada have burgeoned since the IGY. Today the Institute can assist researchers in getting the use of laboratory facilities and field stations for many kinds of work. For example, the Office of Naval Research's Arctic Research Laboratory at Point Barrow, Alaska, offers excellent laboratory and logistical facilities for work in oceanography, sea ice, ecology, geology and soil science, and Arctic climatology. The Institute is establishing this year two stations on Devon Island, N.W.T., for glaciological, marine biological and meteorological studies. Opportunities exist at stations on the Ellesmere Island Ice Shelf and Ice Island T-3 for work in glaciology, sea ice, oceanography, and marine biology. The Institute maintains one small glacier station and is associated with another on the northern slope of Alaska's Brooks Range. These are only a few of the northern research facilities active in 1960.

I am further pleased to announce the Arctic Institute will entertain proposals for support of field research in Antarctica. Applications must be submitted a full year in advance of an Antarctic field season.

Further information about the programme and application forms are available on request from the Arctic Institute of North America, 3485 University Street, Montreal 2, P.Q. or 1530 P Street, N.W., Washington 5, D.C. Applications for 1960 grants should be initiated before November 1, 1960. The Institute will be most grateful to you for presenting this information to your readers. [Although it is too late for applications for grants to be made in respect of 1960, this letter is published to draw attention to the system.]

ROBERT W. MASON
PROJECT CO-ORDINATOR

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15 *August* 1960

ICEBERG ACCUMULATIONS AS COASTAL FEATURES IN ANTARCTICA

At a number of places along the Antarctic coast accumulations of grounded icebergs extend from the shore out into the sea for distances often exceeding 60 miles. In some cases they represent an extension of a glacier tongue which already protrudes some distance from the coast, in others, they appear to have no glacier tongue as their coastal root.

Water sufficiently shallow for stranding the icebergs is a necessary condition for the formation of both types of feature. It is significant that the northern tip of these iceberg tongues invariably coincides with the edge of the continental shelf. Frequently, even in summer, the spaces between the separated icebergs remain choked with fast ice or bay ice so that the iceberg tongue presents a semi-permanent and impenetrable obstacle to ships of every kind. However, in some cases ocean currents appear to sweep away the sea ice in summer, leaving navigable water in narrow lanes between the icebergs.

Because of the length of iceberg tongues, ships attempting to sail along the Antarctic coast are forced to make long northward detours to avoid them. The object of this letter is to stress the importance of iceberg tongues as coastal features in Antarctica, and to make a plea for their accurate delineation on charts. So far little attention has been paid to these features except in the case of the Ninnis and Mertz Glacier Tongues. Where other glacier tongues have been mapped, the seaward extensions of separated icebergs beyond the limits of the solid tongues have generally not been marked, even though they may have been solidly welded together with semi-permanent bay ice.

In 1956, 1958, 1959 and 1960, the ANARE investigated the Dibble Glacier iceberg tongue (long. 135° E.) and delineated its approximate western edge. In each of these summer seasons our ship was forced to detour 70 miles to the north of the main coastline before it could penetrate this tongue. In 1956 and 1960 we investigated a similar iceberg tongue which extended northwards from Cape Southard (long. 121° E.) for 70 miles. Another such tongue appears to extend from Cape Mose (long. 130° E.) northwards for 70 miles to about lat. 65° S. and from Cape Goodenough (long. 127° E.) to about 65° 20′ S. From the Totten Glacier Tongue (long. 117° E.) there almost certainly extends a similar feature. Smaller features may exist at many other places.

Examples of iceberg accumulations in the Australian sector which can be penetrated by ships in summer, probably because currents sweep the grounded icebergs free of obstructing sea ice, are those of the Petersen Bank (long. 111° E.) which extend 50 miles north from "Wilkes" station, those of the Four Ladies Bank (long. 78° E.) near Davis station and those of the Fram Bank (long. 71° E.).

Information concerning the permanence of iceberg tongues and glacier tongues is required. The glacier tongue of the Glacier du Français, at Dumont d'Urville, last summer was found to have practically disappeared, and the

present extensions of the Ninnis and Mertz glacier tongues are apparently far short of what they were when Sir Douglas Mawson first mapped them.

PHILLIP LAW

ANTARCTIC DIVISION,
DEPARTMENT OF EXTERNAL AFFAIRS,
MELBOURNE, AUSTRALIA

8 *June* 1960

THE EDGE OF THE ANTARCTIC CONTINENTAL SHELF

On British and Commonwealth charts of coastal waters the 100-fathom contour is shown, where it exists. This contour has come to be accepted as the edge of the continental shelf. Charts produced for navigational purposes do not delineate the shelf as such.

On Admiralty charts of Antarctica the 100-fathom line and the 1000-fathom line are shown. Charts by the United States Hydrographic Office for Antarctica show the 100-fathom line, 500-fathom line and 1000-fathom line. Charts by the USSR Hydrographic Office show the 200-m. line, 500-m. line, 1000-m. line and 2000-m. line; the areas within the limits of the first three are shaded.

The author considers that a precise criterion should be used for the delineation of the continental shelf in Antarctica. This shelf in many places extends 60 to 100 miles from the coast, it is deeper than that of other continents, its position is of great interest to navigators, oceanographers, biologists, glaciologists and others, and its limit is fairly obviously defined by the very sudden lunge of the sea bed to oceanic depths.

In a number of separate voyages since 1954, the ANARE have carried out ocean soundings from the *Kista Dan*, the *Thala Dan* and the *Magga Dan*. In each approach towards the Antarctic continent care has been taken to record the position where the sudden rise of the sea bed on to the continental shelf occurred, and conversely when leaving Antarctica. The depth of the shelf varies considerably between shoal depths and about 500 m., but most of the shelf soundings lie in the range 300 to 500 m. The transition in depth is shown by the following examples, taken when leaving the shelf:

480 to 1640 m. and deeper in 5 miles of sailing;

380 to 2000 m. and deeper in 7 miles of sailing.

I would like to suggest that maps and charts of Antarctic water delineate as accurately as possible the edge of the continental shelf, using as a criterion not some arbitrarily chosen depth (e.g. 400 fathoms) but the place, irrespective of small variations in depth, where the fairly level sea bed of the continental platform suddenly turns downward to plunge to great depths. This exact, rather than arbitrary, delineation would be of interest to many users of the charts.

PHILLIP LAW

ANTARCTIC DIVISION,
DEPARTMENT OF EXTERNAL AFFAIRS,
MELBOURNE, AUSTRALIA

8 *June* 1960

SCAR BULLETIN

No. 7, January 1961

Fourth meeting of SCAR held in Cambridge, 29 August to 2 September 1960

Present: President: G. R. Laclavère

Delegates: Argentine, R. N. Panzarini; Australia, K. E. Bullen; Belgium J. van Mieghem; Chile, D. H. Fuenzalida; France, G. Weill Japan, T. Nagata; New Zealand, R. W. Willett; Norway T. Gjelsvik; South Africa, J. J. Taljaard; United Kingdom G. de Q. Robin; United States, L. M. Gould; USSR., M. M Somov; IGU., V. Schytt; IUBS., E. B. Worthington; IUGG. G. R. Laclavère.

Observers: SCOR., G. E. R. Deacon; WMO., K. Langlo; Internationa World Day Service (invited), A. H. Shapley.

Advisers: Australia, R. Carrick, H. A. de Dassel, W. J. Gibbs, F. Jacka R. E. Knightley, B. P. Lambert, D. F. Martyn; Belgium F. Bastin, Mlle P. Doyen, J. Loodts, R. Schoonlau; France J. Alt, R. Bost, A. Cailleux, Mlle J. Laclavère, A. Lebeau R. Merle, J. Prevost, R. Rolland; New Zealand, V. Armstrong M. A. F. Barnett, R. H. Clark, J. W. Gadsden, R. S. Unwin Norway, S. Helle, K. Z. Lundquist; South Africa, J. A. King P. W. Thomas; United Kingdom, Sir Miles Clifford, S. Evans Sir Vivian Fuchs, M. W. Holdgate, H. H. Lamb, A. F. Moore W. R. Piggott, A. H. Sheffield, W. D. C. Wiggins; United States A. P. Crary, R. C. Cross, J. Jones, R. C. Peavey, M. J. Rubin M. D. Turner, D. M. Tyree, G. D. Whitmore; USSR, V. L Lebedev.

(1) The Meeting expressed deep regret at the loss of eight scientists in th fire at "Mirnyy" station in August 1960.

(2) *Finance.* The Finance Sub-Committee reported a balance in hand o 31 December 1959 of $3,422.66. Their recommendation that the 1961 sub scription from member countries remain at $500 was accepted. The possibl need to increase this amount in 1962 was noted.

(3) *Antarctic Symposium at Buenos Aires.* The meeting expressed thanks t Argentina for this notable Symposium. Argentina is arranging the publicatio of all papers in seven volumes, the first of which, *General Organization an Exploration and Geography*, is almost ready. Six thousand copies are to b distributed free of charge.

(4) *Poland.* It was reported that Poland had not sent a wintering party t Antarctica, so was not yet eligible to join SCAR.

(5) *President.* Ing. Gen. G. Laclavère was re-elected President for a 3-yea term by unanimous vote.

(6) *International Antarctic Analysis Centre.* The meeting thanked Australi

for operating this important centre, and Argentina, Australia, France and the United States for providing meteorologists there. The work so far accomplished had been very worth while, but much more could be done if additional staff could be recruited from other countries, and if radio communications could be further improved.

(7) *SCAR Indian Ocean Project.* The value of observations which could be made by SCAR ships in the southern part of the Indian Ocean was emphasized.

(8) *Annals of the IGY.* Although CIG is primarily responsible for the volume on the Antarctic programme, the co-operation of SCAR is needed. Two suggestions made will be forwarded to CIG for consideration. One is that the volume contain sections on Organization, Operations and Scientific programmes, while the alternative proposal is that each country active in the IGY Antarctic programme should prepare a chapter on its work covering the years 1959–60.

(9) *Symposium on Biological Research.* An approach to the International Union of Biological Sciences to ask that they act as co-sponsors of an international Symposium on Antarctic Biology to be held in about two years time was approved.

(10) *Register of scientists.* A draft letter was approved for circulation through ICSU to scientific organizations in non-SCAR countries, in addition to circulation to National Committees of SCAR, announcing that the SCAR secretariat proposed to maintain a Register of Scientists willing to work as members of Antarctic expeditions sent out by nations other than their own. Scientists were invited to submit their particulars to the Secretary on a form to be circulated with the letter.

(11) *SCAR and the Antarctic Treaty.* Several delegates reported that they had received communications from their respective Governments in general expressing the following views:

(*a*) The free exchange of information and views among scientists participating in SCAR, and the recommendations concerning scientific programmes and co-operation which have been formulated by SCAR, constitute a most valuable contribution to international scientific co-operation in Antarctica.

(*b*) The Governments recognize that these activities of SCAR constitute the kind of activity contemplated in Article III of the Antarctic Treaty, now pending ratification.

(*c*) It is the intention of the Governments to encourage SCAR to continue this advisory work which is so effectively facilitating international co-operation in scientific investigation in Antarctica.

(12) *Nuclear reactor in Antarctica.* Dr Gould announced that it was planned to install a nuclear reactor, of 1500 kW. capacity, at "NAF McMurdo" in order to provide electrical power for the United States station there. It was hoped to have the reactor in action by March 1962. Extreme care was being taken to ensure that no radiation hazard would be caused by this, and possible later reactors at other United States Antarctic stations.

(13) *IUPAC.* It was decided to invite the International Union of Pure and Applied Chemistry to appoint a geochemist as a delegate to SCAR to assist in the standardizing of techniques of analysis and reporting systems.

(14) *Reporter on Geomagnetism.* Professor T. Nagata was appointed Reporter on Geomagnetism in order to lessen the load of work carried out by Dr Schneider, reporter for upper atmosphere physics.

(15) *Permanent Working Groups.* The meeting approved the formation of the following working groups:

(*a*) Geology. Chairman, R. W. Willett.
(*b*) Meteorology. Chairman, W. J. Gibbs.
(*c*) Biology. Permanent Secretary, R. Carrick.
(*d*) Logistics. Chairman, Rear-Admiral, D. M. Tyree, USN. Secretary, A. P. Crary.

These are in addition to:

(*e*) Cartography. Chairman, Ing. Gen. Laclavère. Secretary, B. P. Lambert.
(*f*) Communications. Chairman, A. H. Sheffield.

The President stressed the fact that SCAR did not have the funds to finance meetings of permanent Working Groups. The normal method of work should be by correspondence. However, if an emergency in communications should arise, the Chairman of that group could call a meeting if necessary. The Secretary of SCAR should be kept fully informed on the activities of Working Groups.

(16) *Assessment of the progress of Antarctic research during 1959–60.* See Appendix I.

(17) *Amendments to scientific investigations recommended by SCAR. SCAR Bulletin*, No. 3, 1959. A number of amendments were proposed by Working Groups and accepted by the Plenary Session subject to ratification by National Committees. These are being circulated and those that receive ratification will be published in *SCAR Bulletin*, No. 8.

(18) *Recommendations of working groups* (*including a resolution by the Plenary Session on Biology*). See Appendix II.

(19) *Time and place of next meeting.* The invitation for the next meeting to be held in New Zealand was accepted, and a date in September or October 1961 was suggested.

(20) The President thanked the Royal Society and the Scott Polar Research Institute for the invitation to hold the meeting in Cambridge, the admirable arrangements made for the meeting and the hospitality extended to delegates and observers.

APPENDIX I

Assessment of the progress of Antarctic research during 1959/60

Working groups were asked to review the progress of scientific research in Antarctica in various disciplines. In most cases preliminary papers had been prepared on the basis of information supplied by specialists from SCAR countries. Although the information was not always complete, and although specialists may differ on some

of the statements, it is considered that publication of these reviews in the *SCAR Bulletin* will be of general interest. The list of members of each working group is given when the group discussed the reviews. The name of the principal author of each review is given at the end of the review, but it should be emphasized that the final document is a compromise between the views of the author and those of the working group.

Meteorology

The following statements give the views of individual authors, since time did not permit a careful study of the reviews by the working group.

A. General studies

Since the IGY many meteorologists have studied data from the Antarctic and the results of their investigations have been presented in a number of scientific journals and at the Symposium on Antarctic Research in New Zealand, February 1958; the Symposium on Antarctic Meteorology, Melbourne, February 1959; and the Antarctic Symposium in Buenos Aires, November 1959. At these Symposia, a considerable amount of new material was presented on the general circulation in Antarctica and adjacent regions, the heat and moisture budgets, the interaction of Antarctic and lower latitude synoptic processes, local effects in the Antarctic and the air flow in the friction level over the Antarctic continent, particularly with reference to katabatic winds. In these fields there have been very significant advances in meteorological knowledge—where formerly there was only meagre data and tentative ideas there is now a very great volume of information and well documented studies.

The study of the Antarctic stratosphere has also advanced greatly and the rapid spring warming and strong westerly stratospheric winds are much better understood.

Some preliminary results have been secured on ozone content in the Antarctic atmosphere and more of this type of information is needed, particularly the vertical distribution of ozone as measured by ozone sondes. This information is likely to be valuable in the study of stratospheric circulation using ozone as a tracer.

A study of the mutual influence between pack ice and atmosphere has progressed only slowly and the importance of this subject certainly warrants a greater volume of attention from meteorologists.

Although considerable advances have been made in the study of the meteorology of the Antarctic it should be emphasized that at least 10 years' observations are necessary to make the results conclusive.

W. J. GIBBS

B. Synoptic observations

The SCAR objective in maintaining the IGY network of surface and upper air observations has been achieved. However, the large oceanic areas have in general remained as serious gaps in the meteorological network.

The routine and operational use of meteorological information has been achieved by the continuation of the IGY communication system, but although this has worked reasonably well there is a definite and urgent need for improvement.

The question of accessibility of Antarctic meteorological data is one to which SCAR should give serious consideration. Data from the IGY and IGC periods have been collected at the WMO Meteorological Data Centre, but SCAR should be active in collaborating with WMO to see that this and subsequent data are readily accessible to all research workers interested in Antarctic meteorology.

W. J. GIBBS

C. Special observations

Renewed emphasis could well be given to the following studies:

surface ozone,
sastrugi,
aerial determinations of albedo,
atmospheric and precipitation chemistry,
ice crystal morphology,
total ozone,
aerosols,
blowing snow.

Extracted from letter of H. Wexler.

D. Atmospheric nuclear radiation

Measurements of atmospheric radioactivity in 1959 were made at "Roi Baudouin" (Belgium); "Little America" and "Amundsen–Scott South Pole" station (U.S.A.) and "Dumont d'Urville" (France).

There are thus three coastal and one inland stations measuring the radioactivity of the atmosphere. This represents a minimum acceptable programme on the Antarctic continent, provided that these four stations continue to function, but it would be very desirable to increase the density of stations.

The recommendations of the CSAGI Working Group on Nuclear Radiations have only been partly followed as far as these concern measurements of tritium and carbon 14 in the atmosphere and the ice.

Attention is drawn to the value of such studies in relation to numerous meteorological and glaciological problems.

E. PICCIOTTO
J. VAN MIEGHEM

E. Rockets, and F. Acoustic probing of the upper atmosphere

No progress in these fields has been reported.

International Antarctic Analysis Centre

The International Antarctic Analysis Centre had continued to operate since its formation in Melbourne early in 1959. Australia has provided accommodation and communication facilities, a staff of twelve assistants and a professional meteorologist as Leader for the Centre. The United States and France have provided professional meteorologists as has the Royal Australian Navy. A senior Argentinian meteorologist will join the centre during late 1959. With the present professional staff an analysis programme embracing routine surface, 700, 500 and 300 mb. daily analyses has been achieved, but the facilities and assistant staff available at the Centre warrant a larger number of professional meteorologists to undertake a comprehensive research programme in addition to the routine synoptic analyses. Only a small amount of research is possible at present with the existing professional staff.

The analysed charts and diagrams are microfilmed and copies provided free of cost by Australia to all SCAR nations.

W. J. GIBB

Upper Atmosphere Physics

F. Jacka (convener), S. Evans, J. W. Gadsden, D. F. Martyn, T. Nagata, R. G. Peavey, R. S. Unwin, G. Weill.

A. Ionosphere

The actual data obtained during the IGC 1959 is not, as yet, available. Preliminary reports suggest that the situation is not very satisfactory. An appreciable part of the IGY network has either stopped work or changed to a minimum schedule which is too small for serious research to be carried out efficiently. In particular, a number of important stations have only obtained ionograms at hourly intervals. Although hourly reduction initially is sufficient for most purposes, more frequent soundings are needed for detailed research.

The ionospheric phenomena appear to be dominated by movements of ionization, both vertically and horizontally, and special experiments are needed to find out the directions of these movements. This calls for a temporary group of relatively closely spaced stations. It is important to try to use several techniques since the movements of a layer are often different from the drift of the ionization, and also since different methods are useful at different levels of magnetic activity. It is probable that a backscatter equipment, placed well outside the auroral zone in the Weddell Sea area, would give a general survey of major layer movements in that zone very economically, though in general this technique is difficult to use at high latitudes.

In view of the limited effort available, there are considerable advantages to be gained by concentrating efforts in particular areas, keeping, of course, a skeleton network in being for general morphological studies. Much useful work could also be done economically by summer expeditions planned to solve particular zonal problems disclosed by the IGY survey.

The following abstracts from the *WWSC Third Report* (Brussels 1959) apply particularly to the Antarctic group of stations:

"Section V. Ionospheric vertical soundings after 1959

The Committee considers that the present stage in the development of the subject calls for special attention to:

(*a*) The maintenance of an adequate network of stations to provide accurate data for geophysical and propagational studies on a world-wide basis;

(*b*) The concentration of stations, and the maintenance of particularly intense programmes of observation and reduction, in zones where close networks of stations provide the possibility of resolving particularly important ionospheric problems by regional study, and the re-allocation of stations to zones where active research is progressing."

The Committee stressed the importance of maintaining new stations and of making a special effort in sunspot minimum years and stated:

"It is clear that the requirements of space research will involve a considerable new effort in ionospheric soundings which was not anticipated before the IGY."

The greatest efforts to improve the operation of existing stations, and to add special additional programmes, are needed in two zones:

The Weddell Sea–South Africa area, which contains the zone where the magnetic dip is abnormally small and the phenomena correspondingly simple.

The Ross Sea–New Zealand area, which contains the opposite extreme.

IGY studies show two major gaps in the existing programme:

(*a*) The measurement of absorption, particularly the dense types associated with storms, is very inadequate. It is probably too late now to attempt to study Type 3 absorption with riometers in the Southern Hemisphere, but a special effort is needed to make riometer studies of storm absorption (Type 2).

(*b*) Measurements of ionospheric drift on both sides of Antarctica are badly needed. These are very difficult to obtain in years of large magnetic activity, and special efforts should be made in the next few years.

It is probable that gaps in the network could be partly covered by using special techniques, for example, oblique incidence soundings between suitably spaced stations, though very little practical experience has as yet been obtained. These measurements have usually been used for communication problems only.

Analyses already completed show that there are special advantages in establishing, if possible, ionospheric measurements at the following positions:

(*a*) At or near "Norway" station.
(*b*) A station in the Bellingshausen Sea area, possibly near lat. 76° S., long. 88° W.
(*c*) A station in South Georgia or the South Sandwich Islands.
(*d*) A station near lat. 85–80° S., long. 20–40° W. to link the South Pole with the Weddell Sea group of stations.
(*e*) The re-establishment of the station at Marion Island.

Where several sites are possible, there are special advantages in putting stations near conjugate points of stations in the Northern Hemisphere. Active work is progressing at present on conjugate point studies of whistlers, blackout, and sporadic E.

W. R. PIGGOTT

B. Aurora and Airglow

The network of observing stations has been maintained, and in some cases extended, in the Antarctic, with some coverage of the sub-Antarctic regions. Observations comprised the classical visual and all-sky camera programmes, together with still photography and moving pictures. Spectrometric and photometric work was extended. Several stations have been using auroral radar as a powerful means of observation, and in this way it is expected to obtain useful information on the movement of ionization. Radio noise studies from aurora are also being carried out, as well as riometer observations of relative ionospheric opacity.

Observational methods and techniques were the subject of special studies, and attention was given to the relative merits of visual and automatic photographic observation of aurora. Progress was reported in the use of colour film in all-sky cameras, and also in detecting subvisual features by means of sequences of varying exposure times.

Much progress was made in analysing the correlation between magnetic disturbances, the occurrence and motion of specific morphological features observed visually or by radar and the appearance and intensity of spectral emissions. Indices of magnetic activity, as well as pulsations, were considered in these studies and the correlations are far from being simple.

Isoauroral maps for limited regions were prepared by several research workers. Although much progress is being achieved, the problem of definition and location of the auroral zone as a whole, and its time changes, is not yet solved in a satisfactory manner.

More rapid progress is desirable in statistical and synoptic analysis of existing data. Statistical analysis is an essential preliminary step to several of the aims stated in the SCAR programme for aurora and airglow; this part of the work should be extended, and should comprise more regional or even hemispherical studies, as are already being done successfully in some branches of upper atmosphere research. So far, synoptic studies have only been possible to a rather limited extent. Slow progress is also being made in auroral height determinations, although new preparations in this direction are under way.

O. SCHNEIDER

C. Geomagnetism

General. Since the IGY, quite a good network for geomagnetic observation over the Antarctic continent has been set up. The density of magnetic observatories in the Antarctic is now nearly sufficient to follow the distribution of geomagnetic daily variation as well as geomagnetic disturbances in this region, especially in comparison with those in the Arctic. Some of these data, though not all, are currently flowing in to the IGY World Data Centres for geomagnetism, and are used for morphological studies on geomagnetic variations over the whole earth. Several remarkable results of such studies were reported in the Buenos Aires Symposium on Antarctic Science.

So far as research on daily and disturbance variations in the geomagnetic field in the Antarctic continent is concerned, it does not seem necessary at present to increase the number of magnetic observatories, but it seems desirable to maintain the present network during the coming sunspot minimum period. However, it must be remarked that there is a great gap between the Antarctic network and the existing network of magnetic observatories in southern countries, Australia, New Zealand, Chile, Argentina and South Africa, except for Macquarie Island and the South Orkney Islands. This situation causes some difficulty in obtaining complete pictures of distribution of geomagnetic variations in the southern hemisphere. In order to fill the gap, it seems desirable to encourage the setting up of magnetic observatories on as many islands as possible in sub-Antarctic areas, such as South Georgia, Crozet, etc.

In this connexion, pen-recording magnetographs may be satisfactory at any station which has insufficient scientific personnel to operate a magnetic observatory of the usual type. Four years' operational experience at "Dumont d'Urville" has shown that this type of instrument is capable of adequate stability and sensitivity while being simple to establish and maintain.

Difficulty has been found in research on geomagnetic secular variation, which is exceptionally large and complicated in Antarctica compared with any other part of the earth's surface. In order to overcome this difficulty, it is recommended that repeat magnetic stations for three components be set up at sub-Antarctic islands, such as South Georgia, Crozet, Bouvet, New Amsterdam, St Paul, Heard, Gough, etc.

Research on geomagnetic disturbances. In the light of recent progress in upper atmosphere and space research, studies on geomagnetic disturbances and related phenomena (auroral displays, ionospheric disturbances, etc.) in the Antarctic have become extremely important. Preliminary studies have already been made, the results showing several promising ways to attack space electromagnetic problems by well-planned co-ordination between mutually conjugate stations in the Antarctic and Arctic.

Magnetic surveys. Results of magnetic surveys made by many traverse parties in the Antarctic in the past few years are very useful for correcting adequately the existing magnetic charts which were compiled from rather poor data. It seems now desirable to take action to compile new magnetic charts based upon the data already available.

T. NAGATA

Cosmic Rays

In the period since January 1959, cosmic ray stations in the Antarctic region have provided valuable records of ground-level intensity and continue to occupy important positions in the world network of observing stations. The long-term objectives of the programme remain unchanged.

In relation to these objectives, maintenance of the programme during the period has been particularly rewarding, as several outstanding solar-related disturbances in cosmic ray intensity have occurred. The most interesting of these events have been the Forbush-type intensity decrease in May 1959, the unusual series of super-

posed intensity decreases of the Forbush-type in July 1959, and the well-defined example of a sudden large intensity increase associated with a solar flare on 4 May 1960.

The value of the ground-level observations at points well distributed in latitude and longitude is enhanced by the increasing availability of supplementary information from measurements of high altitude balloon-borne equipment, earth satellites, and space probes, and substantial progress is expected towards an understanding of the mechanisms controlling such disturbances when analyses of all records are further advanced.

Balloon-borne experiments have so far been carried out mainly in the northern hemisphere. Advantages in extending such work to high southern geomagnetic latitudes are evident and participating groups should examine the possibility of such work at Antarctic stations.

Coverage of the Antarctic region with standard ground-level intensity recorders is now rather better than in previous years and every effort should be made to maintain the existing observatories in the Antarctic, and indeed throughout the world, to accumulate records at all phases of the solar activity cycle. The value of concurrent auroral, magnetic, ionospheric and radio noise observations in elucidating the mechanisms of solar-initiated geophysical disturbances is stressed and it is hoped that wherever possible these programmes can be maintained at a high level.

F. JACKA

Geology

R. W. Willett (Chairman), A. Cailleux, V. E. Fuchs, T. Gjelsvik, L. M. Gould, M. M. Somov.

The progress of geological regional mapping in the Antarctic has been reasonably steady over the last summer season with an increase in geological activity devoted to special problems and special collections for related sciences.

The Argentine geologists have continued regional work in the Ardley Peninsula, King George Island. Previous work on the geology and petrology of Potters Cove in the same island is in the press and an annotated bibiliography of Antarctic Geology has been published.

Australia has carried out geological work leading to 1:250,000 mapping of Edward VIII Gulf, Vestfold Hills, Rauer Group, Larsemann Hills and Fyfe Hills, all areas of high-grade metamorphic rocks. In the Vestfold Hills lake studies have been pursued and rock samples collected for age and palaeomagnetic measurements. In Vincennes Bay, Davis Bay, Henry and Chick Islands, geological reconnaissance has been completed.

Belgian parties worked in east and west regions of the Sør Rondane Mountains mapping the metamorphic rocks of this massif. Isolated nunataks were visited, those of Nord, Romnoes and Seal were found to be massive intrusives. Within the crystalline rocks calcareous lenses were observed. The work was concentrated in the Gunnestadbreen and Hargreavesbreen regions.

Chile is each summer continuing petrographic field study and sampling, mainly to study the relations between igneous bodies in Antarctica and those of Tierra del Fuego–Patagonia. This material is being studied at Santiago during the winter and reports will be published in the near future.

Within the area under action by the Falkland Islands Dependencies Survey; detailed 1:25,000 and 1:5,000 geological mapping has been carried out in the James Ross Island group and west coast of Crown Prince Gustav Channel, Argentine Islands, south-west part of King George Island, Neny Fjord area of Marguerite Bay and parts of north coast of South Georgia. Reconnaissance mapping greater than 1:250,000 was carried out over the north-east part of Livingston Island.

French expeditions based on "Dumont d'Urville" have made petrographic studies on the island of Archipel, together with petrographic studies of moraines at Pointe Géologie and glacial morphology studies.

Both expedition and base activities of the Japanese Antarctic work have resulted in certain geological and geomorphological studies in the vicinity of "Syowa" base, and this work is being continued by the present winter party.

New Zealand continued regional geological work following a pattern started in 1956. During the year under review an area between Barne Inlet and Shackleton Inlet was mapped at a scale of 1:250,000. Between Shackleton Inlet and the Beardmore Glacier the work was of reconnaissance nature only as a result of the loss of a Sno-cat with tragic consequences and the loss of an aircraft. A further area to the south-east of the Beardmore Glacier was mapped in detail by the New Zealand Alpine Club survey party, while the Victoria University expedition continued work in the dry valleys of the Wright and Victoria Glaciers area. Mapping of the entire dry valley area was completed.

Geological work under the sponsorship of the United States National Science Foundation mapped in the Taylor Glacier Dry Valley areas and the Windmill Islands. Geomorphological studies, ice movement, wind drift, etc., were made in the Wilson Piedmont and Taylor Glacier Dry Valley areas and in the McMurdo Sound region. Rock collections for age determination and rock weathering studies were made in the Royal Society Range, Taylor Dry Valley, Marble Point and Gneiss Point.

The Soviet Union continued geological work during the summer of 1959/60 in the mountains south of "Lazarev" station. The work has followed the same programme as that of the previous 1958/59 summer.

R. W. WILLETT

Crustal Geophysics

K. E. Bullen (Chairman), R. H. Clark, A. P. Crary, G. E. R. Deacon, T. Nagata, G. de Q. Robin, V. Schytt.

A. Seismology

Report on progress. These notes deal with the station seismology as ice-thickness measurements by seismic methods are dealt with under Glaciology.

Station activity. Station activity has continued at approximately the same level as during the IGY. It is clear that there are not sufficient stations as yet to enable more than a few shocks in Antarctica proper to be located each year.

Antarctic seismicity. All investigations show that the seismicity of Antarctica is abnormally low. Local minor shocks have been recorded at "Scott" base and at Halley Bay. On the other hand Antarctic stations have located many epicentres not detected by other stations which were a limited distance to the north of the continent. These epicentres have been found in the Ross and Weddell Sea areas, in the vicinity of the Balleny Islands, and also in the region between Antarctica and the southern continents.

Crustal structure. Refraction shooting has yielded some *P*-wave velocities in rocks beneath the ice sheet. Measurements of dispersion of surface seismic waves over various Antarctic paths has been made with a view to estimating the depth to the Mohorovicic discontinuity. Some of these results indicate a crustal thickness of order 35 km. for part of "East" Antarctica while some other interpretations are still tentative.

Distant earthquakes. Most stations have recorded numerous distant earthquakes, and so contributed to global seismology.

The United States Coast and Geodetic Survey reports that data from Antarctic seismological stations have enabled improved determinations to be made of distant epicentres, and have in particular proved valuable in studies of the Earth's core.

Microseisms. There is some evidence that Antarctic 3 to 10 sec. microseisms are less in winter than in summer. This is in contrast to what happens in temperate countries where winter storms produce greater activity. There are probably two main sources, associated with depressions passing to the northwards and with coastal waves. The lower activity in the Antarctic winter may be due to the pack ice keeping waves away from the coast. Further study might allow changes in mean activity to be used as some indication of the extent of the pack-ice fringe. K. E. BULLEN

B. Glaciology

The extensive operations of inland expeditions to determine the general features of the Antarctic ice were continued during the 1959 season. A notable contribution was made by the USSR with a line of stations from "Komsomolskaya" to "Vostok" to the United States South Pole station, linking the USSR network of "east Antarctica" traverses to the British Commonwealth Trans-Antarctic Expedition profile made in 1957–58. The average thickness of the ice along this USSR profile was about 3290 m., and the average elevation of the ice sheet 3240 m. indicating that the level of the subice rock is about sea level. The United States sent two traverse teams into the field in 1959, one to the Victoria Land plateau where a line north-west from the Skelton Glacier connected to the southernmost point of the French traverse of 1957–58, then ran due east to the mountainous area south of Rennick Bay. In the area covered by this traverse most of the bedrock was found to be below sea level. In Marie Byrd Land a traverse operated between the "Byrd" station and the Amundsen Sea with most of the area having relatively thin ice. Exposed ranges and nunataks were mapped and some coastline ice shelf delineated. Extensive ice thickness studies were also made by the Belgians in 1959 from the "Roi Baudouin Base" to the Sør-Rondane Mountains and the polar plateau.

The need is stressed for determination of the variation of *P*-wave velocity at depths below the surface layers. Full presentation or such data is necessary. In addition travel times of reflexions and source data should be included in reports.

At all stations on the Antarctic continent not located on a rock surface, measurements of the accumulation and/or ablation at the surface continue. An important contribution was made by the re-measurements of accumulation and surface elevation by Norwegian scientists at the "Maudheim" station which was last visited in 1952. At many Antarctic stations pit studies of stratigraphy, temperature at depth and crystal character are under routine investigation.

Absolute and relative movement studies of the ice, floating in some cases and grounded in others, are being carried out near the stations of "Scott", "Roi Baudouin", "Norway", Halley Bay, "Ellsworth", "Byrd" and others. Movement stakes were located, and in some instances re-surveyed, in five glaciers of the Sør Rondane Mountains. Measurements were made of the volume of ice flow from the Skelton Glacier on the western side of the Ross Ice Shelf in 1959. The initial survey was completed along the northern front of the Ross Ice Shelf for re-surveying in 1962 or 1963. At many stations special observations are contributing to glaciological knowledge such as geochemical studies, snowdrift problems, sea ice investigations, etc.

Attention of the SCAR delegates is invited to new fields of glaciological research that have been suggested. These include thermal conductivity measurements in the snow and firn layers, electrical properties of drifting snow, measurements of melting at the bottom of shelf ice and location of the transition zone from temperate

to cold ice along the Antarctic peninsula. Other observations for which increased activities have been suggested are measurements on glacier discharges, long-term budget studies and increased seismic velocity determinations for the subice rock material.

A. P. CRARY

C. *Gravity*

Many new gravity stations were occupied in Antarctica during 1959. On the traverses of the USSR between "Komsomolskaya", "Vostok" and the South Pole the gravity observations showed 100 to 200 milligal negative anomalies after Bouguer reduction to sea-level. The USSR observations have tied their Eastern Antarctic network to the South Pole station where previous British and United States observations were made. On the United States oversnow traverse in Victoria Land, gravity observations included a tie to the furthest south gravity station of the French traverse of 1957, and in Marie Byrd Land gravity observations were made between the "Byrd" station and the Amundsen Sea. From the "Roi Baudouin" Base the Belgians have made gravity measurements into the Sør Rondane Mountains where many stations were located on rock surfaces.

Despite these increased gravity meter ties, the need for increased pendulum gravity ties between Antarctica and first order stations in Australia, New Zealand, South Africa and South America, as well as between coastal stations of Antarctica, should be again emphasized.

Gravity measurements were made in Ross Island and McMurdo Sound areas by New Zealand and United States scientists. Extensive gravity work was carried out along the peninsula by British, Argentinean and Chilean workers, with the British making gravity ties from the peninsula to Port Stanley, Falkland Islands. United States gravity observations made during the cruise of the *Glacier* include values on the Thurston Peninsula, Buls Island, Deception Island, Falkland Islands and Buenos Aires. A further tie was made between McMurdo Sound and the ice sheet satellite of "Wilkes" station during a flight in early December 1959.

The gravity programme appears to be progressing well with respect to investigations recommended by SCAR, with the possible exception of sea-borne gravity meter observations. With the continual improvement of meters and stabilized platforms, it is anticipated that this phase of the programme will be more active in the near future.

A. P. CRARY

Cartography

G. R. Laclavère (Chairman), B. P. Lambert (Secretary), T. Gjelsvik, S. Helle, A. Lebeau, J. Loodts, K. Z. Lundquist, R. N. M. Panzarini, V. Schytt, M. M. Somov, P. W. Thomas, M. D. Turner, G. D. Whitmore, W. D. C. Wiggins, R. W. Willett.

No general review of the progress of field surveys or map production has been attempted. The secretary of SCAR has prepared the following notes from the report of the Working Group on Cartography at the 4th meeting of SCAR. Further information of the activity of this group is shown in Appendix II under Cartography:

The free interchange between member countries of certain mapping material, the continued production of 1:10,000,000, 1:6,000,000 and 1:3,000,000 topographic maps of Antarctica, and the giving of advance notice of field-mapping activities among member nations, are now in operation.

A recommended set of conventional signs for use on topographic maps of Antarctica was prepared at the 4th meeting of SCAR. Certain technical specifications for maps of Antarctica prepared by the 3rd meeting of SCAR have been very largely adopted.

Oceanography

M. M. Somov (Reporter), A. Cailleux, A. P. Crary, G. E. R. Deacon.

British expeditions have studied sea ice distribution, thermophysical properties of sea ice at Halley Bay, tides at South Georgia and the Argentine Islands, and ocean wave penetration of the pack ice. Some towed magnetometer work has been started.

Argentina made an oceanographic cross-section of the northern part of the Weddell Sea studying physical, chemical, geological and biological phenomena. The whole water column was studied. All ships crossing Drake Passage made surface oceanographic observations in order to establish the exact location of the Antarctic Convergence Zone.

The Belgian expedition twice carried out oceanographic cross-sections from 0 to 100 m. depth between Cape Town and "Roi Baudouin". Depths measurements, dredge and grab stations and tidal observations were carried out in Breidvika. Visual observations on the currents, ice drift and on the colour of the sea were accomplished.

The work of the New Zealand expedition was concentrated in the Ross Sea area. Eight temperature salinity stations were completed, and ^{14}C samples were taken at two localities. Observations have also been taken en route to and from the Antarctic by means of of bathythermographs with the emphasis on Convergence studies.

The Soviet oceanographic expedition completed the standard cross-section along 20° E. meridian consisting of nine complex oceanographic stations covering the whole water thickness. Ice reconnaissance flights were carried out regularly throughout the year over the Davis Sea and adjacent parts of the ocean. At "Mirnyy" observatory coastal oceanographic observations were made. A cruise around the Antarctic was accomplished from 20° E. to Drake Strait in an easterly direction, on which eleven complete oceanographic stations were occupied and current observations by an electromagnetic method were carried out as well as radar observations on ice and icebergs, temperature and salinity observations and continuous echo sounding. By means of radar, surveying, photography and sketching a more exact determination of the position, size and configuration of Peter I Øy was established. Depth soundings were made around the island.

United States oceanographic observations were carried out on four ships in the Bellingshausen Sea and Drake Strait area. Standard oceanographic stations were accomplished as frequently as possible. Studies conducted while ships were underway included bathythermograph observations and continuous echo soundings. A notable paucity of bottom-dwelling marine life was found along the Bellingshausen Sea coast. At McMurdo Sound coastal observations included measurements of water temperatures, salinities, currents and ice conditions.

The French oceanographic expedition occupied sixty bathythermograph stations in the Antarctic Convergence zone en route from Tasmania to Terre Adélie. Arrangements were made to provide for sea level observations at Ile Kerguelen and at Terre Adélie and for a hydrographical survey of the Ile de Pétrel area in 1961.

The Japanese Antarctic Research Expedition accomplished eleven serial oceanographical stations in the Lützow–Holmbukta area. Plankton samples were obtained. Surface observations were carried out en route from Japan to the Antarctic. During the cruise across the Antarctic Convergence Zone these observations were accompanied by bathythermograph measurements. Ice observations were made in Antarctic waters. Several ice reconnaissance helicopter flights were undertaken.

Australia and Norway reported that no oceanographic observations were made

in the 1959–60 season by their ships, while no reports from Chile and South Africa are available.

It is clear that oceanographic research in the Antarctic is at a lower level than that in land-based disciplines. This is largely due to the fact that observations are frequently only incidental to the transport work of an expedition ship, and their time and place are dictated by other than purely scientific considerations. In addition few expedition ships attempt observations covering the whole water column. Oceanographically Antarctic waters remain the least known in the world though they play an important role in the water circulation of the southern hemisphere and of the whole World Ocean. Therefore SCAR recommends that lively effort should be made to widen oceanographic investigations in the Antarctic, even at the expense of land-based research.

M. M. SOMOV

Biology

The following notes were prepared by the SCAR reporter, who draws attention to the fact that the SCAR programme in Terrestrial Biology was not drafted until March 1959, and could not therefore be put into operation until 1960:

Prior to 1957, several nations had undertaken research in terrestrial biology, and some of these continue to pursue it more or less independently. The United Kingdom publications on ecology and reproduction of seals and penguins are outstanding; Australia has published on a wide range of subjects, and other nations also. Bird-banding, and to a lesser extent, seal-branding have been done by most nations, and the results justify much expansion.

Organized international co-operation has been limited to the United States scheme for banding McCormick's Skua (*Catharacta skua maccormicki*). There has been exchange of collected material.

Although a few nations are actively engaged in fairly comprehensive programmes, the general progress since SCAR took over from CSAGI in 1959 has been slight. The biogeographical gaps are considerable. Much systematic collecting, both of specimens and of standard life-cycle data, remains to be done. Much better knowledge of the food-chain relationships of terrestrial forms which feed at sea is required. Much ecological, physiological and behavioural study of mammals and birds remains to be attempted. It cannot yet be said that any part of the current SCAR programme could be dropped.

Antarctic terrestrial biology is still at a relatively early stage of development. National participation requires to be widened, and international co-ordination developed so that biogeographical surveys will be more complete and standard, and so that cognate specific projects in each field will obtain mutual stimulation.

R. CARRICK

The Working Group on Terrestrial Biology, which included the following biologists: R. Carrick, M. Holdgate, J. Prevost and A. W. Worthington, considered that the present research effort in the life sciences in the Antarctic falls considerably short of that in the physical sciences.

Medical Research

Physiology. Many medical officers have made studies in this field, and some expeditions have continuous programmes of physiological research under way. Studies are known to have been made by expeditions from Argentina, Australia, Belgium, France, Japan, New Zealand, the United Kingdom, USSR and the United States. Extreme climatic conditions in which studies of human physiology have been made exist at the USSR "Vostok" station and the United States "Amundsen–Scott South Pole" station.

The following review refers mainly to studies by United Kingdom and United States expeditions.

Human physiology. Subjects studied include:

Food intake during the year, both at base and during sledging. Weight changes and the thickness of the subcutaneous fat have also been followed. Food intake in terms of calories is high, especially during sledging, but in general weight changes are small. There is evidence of a seasonal weight change with a rise during the winter and a fall in the summer; there are corresponding changes in subcutaneous fat thickness. Some estimates of energy expenditure have been made; these are in general high. It appears that the high food intake is due to the increased level of energy expenditure, rather than a direct effect of low temperature on metabolism.

Sleep rhythms have been followed in a large number of subjects for periods of up to one year. Although there may be some disruption of sleep patterns during time of 24-hour light or 24-hour darkness, such disruption varies very considerably from base to base, and is markedly affected by the social organization. Average duration of sleep does not differ during different seasons of the year.

Work continues in an attempt to obtain evidence of physiological adaptation to cold in man. Clothing records suggest that less clothing is worn by the adapted individual, but this requires confirmation. Cold diuresis studies have begun, in the expectation that adaptation to cold decreases the diuretic response to a cold stimulus.

The micro-climate of man is now being studied in some detail. New techniques have been developed for recording the ambient temperature to which a subject is exposed during the 24 hours. Studies of the heat gained from solar and reflected radiation have indicated that in the conditions of the polar summer with up to 24 hours sunlight at a low altitude heat gain can be very considerable.

These studies should now be extended to cover the radiant heat loss to the sky during winter.

Animal physiology. Studies of the nutrition of the husky dog have continued at United Kingdom bases. These show that the energy expenditure of the dog approaches that of man, and, in relation to body weight is very high.

Studies of the physiology of penguins cover skin, body and incubating egg temperatures. A study of water metabolism of the penguin with emphasis on the role of sea water and salt in the food is being continued at "Hallett" station. It was found that newly hatched chicks have a well-developed salt gland that can function immediately after hatching, and that the capacity for excretion of salt increases during development. In a series of tests, birds subjected to water loads were noted not to respond by heavy diuresis.

A programme of erythrocyte counts and haemoglobin estimates in seals and fishes, by means of haemoglobin and erythrocyte count and microscopic examination, was carried out in the Weddell Sea area during December 1958 to January 1959.

Fish metabolism studies by means of oxygen consumption rates relative to weight and temperature were made at McMurdo Sound from November 1958 to January 1959.

A programme of ecological and physiological studies of marine animals commenced in 1959 will be continued during the 1960–61 season. This programme includes studies of fish metabolism as related to variations in temperature, body weight and activity during October to March. Comparisons of metabolism and growth rates will be made between sedentary bottom species and more active pelagic forms found under the ice cover at McMurdo Sound.

Comments. It would be valuable if there could be more parallel studies on the food intake and energy expenditure of man in the cold. There is still considerable controversy regarding food requirements in the cold, and whether there is a specific effect of cold.

Systematic studies of human thermal balance during different activities in the Antarctic should be encouraged.

The psychology of isolated groups is also in need of more study.

Research of the physiological type of Antarctic animals is unique and should be supported.

Whenever practical standardization of techniques and collaboration in human studies should be encouraged. This may be particularly profitable in the case of nutritional surveys and field thermal balance studies. This would mean that more data from different locations could be obtained in a shorter space of time.

Since no specialists in medical research were present at the 4th meeting of SCAR, the above summary was based on a review prepared by Dr O. G. Edholm (United Kingdom) supplemented by comments from the United States Polar Committee and notes on the United States programme prepared by Dr Rodahl.

APPENDIX II

Recommendations of Working Groups

The recommendations contained in the reports of working groups (*a–k* below) were accepted. Resolutions by the Plenary Session on the report of the Working Groups on Biology, Geology and Meteorology appear at the end of the recommendations of those groups.

Working Group on Meteorology (Chairman, W. J. Gibbs)

(*a*) That, in view of the summary of meteorological requirements attached hereto, and the importance of these requirements, SCAR strongly requests its members to give urgent assistance in arranging the communication facilities necessary to meet the requirements, and requests WMO to take cognizance of the needs expressed when considering telecommunication arrangements for the southern hemisphere. Members are asked to examine the attachment and inform the Secretary of SCAR of any necessary amendments or addition thereto.

Summary of meteorological requirement for synoptic data

Note: for the purposes of this summary "Antarctica" is taken to include sub-Antarctic islands.

	From within Antarctica		From outside Antarctica	
tation or country	Information required	Frequency of collection	Information required	Frequency of collection
"NAF McMurdo"	All available surface and upper air data	Four times daily in summer, two in winter	Selection of data from Australia, New Zealand, S. Africa, S. America. Analyses from IAAC, etc.	Twice daily?
'Mirnyy" IAAC	No details but thought to be similar to "NAF McMurdo"			
	All available surface and upper air data	A minimum of twice daily	Selected surface and upper air reports from S. Africa, S. America, New Zealand and Australia	Once or twice daily

Station or country	From within Antarctica: Information required	From within Antarctica: Frequency of collection	From outside Antarctica: Information required	From outside Antarctica: Frequenc collecti
"Amundsen–Scott" "Byrd" "Hallet" "Scott-Base" "Roi Baudoin" Halley Bay S. African base "Wilkes" "Davis" "Syowa" Mawson "Dumont d'Urville" Stanley	Generally limited requirement for information from adjacent bases, forecasts required at times	Generally not more than once or twice daily	Requirement usually restricted to analysis state-ments	Once or perhap twice d
"Vostok" "Lazarev" "Komsomolskaya"	Requirement likely to be similar to Halley Bay, etc.			
South Africa	Surface and upper air data from coastline between 90° W. eastward to 90° E.	Twice daily	—	—
New Zealand	Surface and upper air data from Antarctic sector between 90° E. eastward to 90° W.	Summer season four times daily. Winter season twice daily	—	—
France (Kerguelen)	As for S. Africa plus IAAC analyses		—	—
Australia (apart from IAAC)	Surface and upper air data from coast of east Antarctica	Once daily	—	—
U.S. requirement in New Zealand	In summer season requirement as for "NAF McMurdo". Nil in winter	Four times daily	—	—
Argentina and Chile	For S. America section of Antarctica	Once daily?	—	—
USSR	As for "Mirnyy"?	Once daily?	—	—

(*b*) that SCAR commends the members of the IAAC* and Australian authorities fo the achievements of the IAAC in producing useful analyses and providing microfilm copies thereof, and looks forward to an increase in the effectiveness of analysis state ments at present broadcast by radio when the delay in their issue can be reduced following the expected improvement in communications. SCAR also commends th attachment of meteorologists to the Centre by Argentina, Australia, France and United States, and requests all members of SCAR to indicate to the Secretary by 1 November 1960 their intentions regarding attachment of meteorologists to th Centre in the future. SCAR also requests the WMO to invite its members similarly to indicate their future intentions in this regard.

(*c*) that SCAR, recognizing the significant advances made in Antarctic meteoro logy following the IGY and post-IGY programme of meteorological observations

* International Antarctic Analysis Centre, Melbourne, Australia.

and desiring to maintain this progress, urges members to give special attention to the following:

(i) the need to maintain, and where possible add to, existing stations and carry out comprehensive meteorological observations;

(ii) the need to renew efforts to place observing teams on uninhabited sub-Antarctic islands, or failing this, to establish automatic weather stations thereon;

(iii) the spectacular success of the United States satellite Tiros I, which promises a very significant increase in the knowledge of the distribution of cloud and pack ice in Antarctic and sub-Antarctic regions. Arrangements should be made to distribute the results of the analysis of such data for operational and research purposes;

(iv) pack ice reconnaissance by sea and air should be intensified in anticipation of pack-ice observations by artificial satellites. It is desirable that a member or members of SCAR should undertake the collection and analysis of the information;

(v) noting the successes achieved by the United States in the use of drop-sondes and the USSR with observations from meteorological reconnaissance aircraft, commends these methods to the attention of other nations;

(vi) noting that there are still expedition and other ships in higher latitudes of the southern hemisphere whose meteorological observations are not available in routine meteorological synoptic messages, members should ensure that all ships operating in these waters (including tankers) are recruited to make observations, and when operating south of 50° S. transmit them both to an Antarctic station and to the appropriate radio station recommended by WMO. The South African Weather Bureau is to be commended for its action in organizing reports from whaling ships, and should be requested to take care of any additional arrangements necessary in providing ciphers for whalers and tankers. Efforts should be made to ensure that oceanographical and similar expeditions in Antarctic and sub-Antarctic waters are equipped to make comprehensive meteorological observations;

(vii) noting that automatic weather stations housed in anchored buoys are likely to provide valuable meteorological information in sub-Antarctic waters, members should strive to develop and station these at advantageous locations, bearing in mind the relevant recommendations of WMO (Resolution T21 of EC-XII), Rec A, 7 (CMM-11), Res. A.3 (CMM-11);

(viii) the measure of success in the use of land-based automatic weather stations in Antarctica suggests that it would be profitable to continue and extend the operation of these stations;

(ix) the technique for measuring snow drift and the results of these measurements described by Mellor, and by Mellor and Radok, in papers to be published in the report of the Proceedings of the Symposium on Antarctic Meteorology held in Melbourne in 1959, indicate that the application of this technique in a network at Antarctic stations would yield essential information for the study of the mass budget of moisture;

(x) noting the valuable measurements of ozone made at a number of stations in Antarctica, it is desirable that the observations should be intensified and extended to form a synoptic network particularly including sub-Antarctic islands;

(xi) the number of stations at which atmospheric nuclear radiation measurements are made should be increased and the importance of measuring isotopes, such as Tritium and ^{14}C, in the atmosphere and the ice is stressed;

(xii) noting the work done in Canada and Sweden on the electrification of blowing snow and its effects on radio communications, members may consider the establishment of a programme of observations of this phenomenon.

(*d*) that SCAR, noting that certain IGY meteorological data for the Antarctic is still not available at the WMO Data Centre, urges members concerned to supply the missing data as soon as possible. In view of the very great importance of post IGY Antarctic and sub-Antarctic data for meteorological research, SCAR further suggests that members who are not planning to place this data on punched cards should inquire through the WMO whether another member would be prepared to arrange punching of this data.

(*e*) that SCAR notes with satisfaction the progress made by South Africa in its project for synoptic analysis of the IGY southern hemisphere surface and 500 mb data, and records its appreciation of the effort involved and the great value of these analyses to research workers in the future.

(*f*) that SCAR, noting the remarks of the representative of SCOR attending this meeting, regarding the desirability of close co-operation between meteorologists and oceanographers in studying related problems, urges National Committees to insure, that as far as possible planning and carrying out of meteorological and oceanographical observations and investigations should be adequately co-ordinated.

(*g*) that in view of the importance of CLIMAT and CLIMAT TEMP data from Antarctic and sub-Antarctic regions, members should prepare and despatch such information promptly and regularly.

SCAR also urges WMO to arrange for the provision of a code for CLIMAT WIND and suggests that the following might be approved for interim use:

CLIMAT TEMP WIND HHHHT $TTT_dT_dT_d$ Xddff, where ddff is the vector mean wind.

SCAR also suggests that WMO might consider the reporting of monthly vector mean surface wind from Antarctic and sub-Antarctic stations, using a group Xddff appended to the existing CLIMAT code.

(*h*) that SCAR requests WMO to take speedy action to amend the code for reporting wind direction at the South Pole station so that wind from longitude

0° is reported as 36
90° E. is reported as 09
180° is reported as 18
90° W. is reported as 27, etc.

(*i*) that SCAR, saddened at its fourth meeting by the notice of the tragic fire at "Mirnyy" in which eight meteorologists perished, expresses deep regret to the USSR member, and asks that its heartfelt sympathy be extended to the families of the men who gave their lives in the cause of science in Antarctica.

(*j*) that SCAR, noting that the WMO Executive Committee in its twelfth session (Resolution T.3, EC-12) decided that the use of the tropopause group in the TEMP code [FM35B] is optional, and that if it is used it shall be in complete form, and noting that a recent investigation in the United States suggests that tropopause data have forecasting significance in Antarctica, urges its members to instruct their Antarctic stations to include §11 of FM35-B in its complete form in all TEMP messages as soon as possible.

The final Plenary Session approved the formation of a Permanent Working Group on Meteorology under the chairmanship of W. J. Gibbs.

Working Group on Upper Atmosphere Physics. (Convener, F. Jacka)

Ionosphere

(*a*) That the need to regard ionospheric observation in the Antarctic as a research rather than a routine be stressed to all concerned;

(*b*) that Ionograms, taken not less frequently than at quarter hourly intervals, should be obtained at all ionospheric stations;

(*c*) that special effort be made to operate ionospheric stations in the Weddell Sea and Ross Sea chains as full stations;

(*d*) that special effort be made to deploy riometers in the Antarctic;

(*e*) that special effort be made to deploy ionospheric drift measuring equipment at several stations in the Antarctic;

(*f*) that the recommendations of IPS on the desirable minimum network of ionospheric sounding stations for prediction purposes be sought and adopted.

Auroral and airglow physics

(*a*) Atlas of auroral forms and auroral nomenclature. That SCAR should welcome the decision of the IAGA committee on aurora and airglow to revise the *Atlas of Auroral Forms* and auroral nomenclature, and urges SCAR nations to offer their full support to this project.

(*b*) World data centres for auroral data. That SCAR should call the attention of the CIG and its reporter for aurora to the urgent need to revise and simplify the IGY recommendations for the type and quantity of auroral data to be sent to World Data Centres, and recommends that the national auroral reporters for the countries involved in Antarctic work be specifically consulted by CIG in arriving at this revision, recognizing the possibility that the northern and southern auroral data flow may have to be different on account of the special requirements associated with the operation of Antarctic expeditions. The latter may have to be restricted to those data required to permit a catalogue of sources and types of data held at individual central laboratories to be maintained.

Geomagnetism

(*a*) That co-ordination between Antarctic and Arctic magnetic stations, and special co-operative observational programmes on geomagnetic disturbances (together with auroral and ionospheric observations) be continued and developed;

(*b*) the setting up of repeat magnetic stations on as many islands as possible in the Antarctic and in the sub-Antarctic ocean areas, in order to measure the unusual geomagnetic secular variation observed in these areas;

(*c*) the setting up of magnetic observatories so far as possible on islands in the sub-Antarctic area;

(*d*) that SCAR recognizes that there is need for immediate action

(i) to compile Antarctic magnetic charts using all results of magnetic surveys carried out hitherto,

(ii) to establish the morphology of geomagnetic daily variations and disturbances in the Antarctic area using data obtained during the IGY and IGC 1959.

World magnetic survey (Convener, T. Nagata)

(*a*) That three component surveys be carried out during 1960 to 1965 over Antarctica and the surrounding ocean area by SCAR member nations, as far as possible according to the technical instructions proposed by the IUGG World Magnetic

Survey Committee (Resolution No. 16 XIth Assembly, Toronto, 1957). Where it i not possible to measure three components, one-component surveys (F or Z) carrie out from ships or by sledging parties are still valuable;

(*b*) that existing magnetic observatories should preserve the accuracy of thei base line values, as well as scale values, as recommended in the *IGY Instructio Manual* at least until 1965.0 in order to maintain a basic reference network for th surveys;

(*c*) that repeat stations should be established to extend knowledge of the secula variation in the gaps between magnetic observatories. The secular information i necessary for the reduction of the survey data to a particular epoch (1965.0) and fo the intrinsic interest in the origin of the main field. Repeat stations should b established at a fixed mark to be visited as often as possible, and at least annuall during 1961 to 1965.

Interdiscipline co-operation

(*a*) That SCAR draws attention to the very great benefits to be derived fro close co-operation between those working on different aspects of upper atmospher physics at the one station.

Sunspot minimum programme

(*a*) That SCAR supports specific upper atmosphere research projects which ca for a measure of international co-operation in the Antarctic. Some such projec are of particular importance around the time of solar activity minimum since the will complement IGY projects. In this connexion, the importance of associate Arctic studies should not be overlooked.

In view of the time needed to construct equipment, train operators and deploy th equipment in the Antarctic, it is desirable that plans for any special projects durin sunspot minimum—the sunspot minimum programme—should be discussed a soon as possible;

(*b*) that among other projects for the sunspot minimum programme should b a standardized all-sky camera auroral programme timed as follows:

(i) the initial discussion, planning and design to be completed by the end the fifth SCAR meeting;
(ii) construction of equipment to be completed during 1962;
(iii) rigorous field testing to be carried out during 1963;
(iv) the equipment to be operated throughout 1964 and 1965.

Analysis of existing data from the Antarctic reveals that standardization observational technique is essential. The proposed network should cover the regio centred on lat. 75° S., long. 135° E., and of radius approximately 35°.

The project should be co-ordinated by the convenor of the Working Group Upper Atmosphere Physics;

(*c*) that during 1964 and 1965 other equipment available for auroral observatio (e.g. photometers, radars, etc.) be used to supplement this main project. Howeve no standardization (apart from appropriate calibration) of these equipments envisaged;

(*d*) that, during the period 1961 to 1963 inclusive, auroral observatories in th Antarctic concentrate their efforts on particular research projects of interest individual workers.

Working Group on Geology (Chairman, R. W. Willett)

(*a*) That member nations when preparing regional geological maps do so sheet by sheet, each sheet carrying a brief, approximately 5,000 word, summary of the geology thereon. This is in no way considered to replace geological reports and bulletins, but is designed to enable the maps to be available for other specialist workers without the inevitable delay arising from the preparation of bulletin texts;

(*b*) that where possible geological map series be published on the same scale as the corresponding topographic map series. For large-scale maps it is recommended that SCAR member nations consider, for discussionn at next SCAR meeting, the possible uniform use of certain large scales for detailed geological maps;

(*c*) that the member nations of SCAR continue geological mapping in the Antarctic. That colour schemes, symbols, and abreviations be circulated to all SCAR member nations for comments, and that a correlation of these comments be presented to the next SCAR meeting;

(*d*) that, prior to the next meeting of SCAR, the member nations give consideration to the following points for discussions:

(i) production of geological maps,
(ii) geological symbols and colours,
(iii) stratographic and formation names, correlation, proposals to be prepared for next meeting,
(iv) co-ordination of isotope dating of Antarctic rocks,
(v) any other relevant matter.

(*e*) that the Soviet proposals for geological mapping in the Antarctic be circulated with a view to discussion at the next SCAR meeting;

(*f*) that the Oceanographic Group be urged to continue work on submarine geological studies. It is further recommended that deep samples by the piston coring method be obtained. The Working Group draws attention to the desirability of more rapid publication of bathymetric and echo sounding data.

The Working Group notes the existence of overlap in the proposed work programmes of several participating nations and suggests that these differences be resolved bi-laterally in order to prevent any unnecessary waste of man-power and logistics.

The Plenary Session approved the formation of a permanent Working Group on Geology under the chairmanship of Dr R. W. Willett.

Working Group on Cartography (Chairman, G. R. Laclavère)

(*a*) That all member nations use in their topographic maps the conventional signs recommended by the Working Group on Cartography; and requests the Secretary of that Working Group to distribute these conventional signs in published form to members of SCAR and to other interested agencies.

(*b*) that

(i) those member nations which have not already done so, immediately exchange their gazetteers of place names, as recommended by SCAR at its Third Meeting;
(ii) in future, members of SCAR distribute, on a similar basis, amendments to their gazetteers giving early details of any new place names decided upon;
(iii) that any member nations finding that they are in conflict with respect to place names endeavour to resolve their differences bi-laterally.

(*c*) that SCAR, having considered the statement submitted jointly by the United

States Advisory Committee on Antarctic Names and the United Kingdom Antarctic Place Names committee on the subject of under-ice features, recommends that features lying under an ice cover should be named according to the already adopted geographical terminology prefixed with the term "subglacial"; the abbreviations of this prefix on maps being "Sg";

(*d*) that member nations prepare and maintain air photography flight index diagrams, preferably on 1:1,000,000 scale base maps, showing appropriate information with respect to:

(i) location, date and identification of air photography,
(ii) scale of photography and camera characteristics,
(iii) whether photography consists of verticals and/or obliques,
(iv) evaluation of quality;
(v) that the originating countries forward each year to every other member nation, and the Secretaries General of IUGG and IGU, one up-to-date copy of their photo indexes;

(*e*) that nations intending to concentrate their future mapping efforts at scales not less than 1:3,000,000 in any particular area, as shown in the index prepared by the USSR, should inform SCAR accordingly at its regular meetings, and that wherever possible nations should co-operate to cover whole sheets;

(*f*) that SCAR, wishing to encourage the production of scientific atlases of Antarctica, recommends that member nations assist wherever practicable, and that where such assistance is given, it be duly acknowledged in the publication.

The Working Group draws attention to the fact that the proposed photogrammetric mapping programmes of the following countries appear to overlap:

(i) USSR and Australia—in respect of the coastal area between long. 78° and 110° E.
(ii) Belgium and Norway and USSR—in the vicinity of "Lazarev" station.
(iii) Belgium and Japan—in respect of the coastal area between long. 30° and 40° E.

Working Group on Crustal Geophysics (Chairman, Professor K. E. Bullen)

Seismology

(*a*) That additional centres should be encouraged to undertake wave studies, and that increased attention be given to refraction shooting which will yield knowledge of seismic velocities and layer thicknesses down to, and possibly below, the Mohorovicic discontinuity. (It is to be noted that for *P* waves the highest efficiency is obtained by having explosions in the sea or lakes.)

(*b*) that more short-period seismographs should be installed at existing stations to assist in studying local earthquakes;

c) that, between now and the next SCAR meeting, National Committees give consideration to the setting up of a regional Antarctic seismological centre. The function of this centre would be to compile, publish and distribute in monthly (or quarterly) bulletins, details of seismic readings taken at Antarctic stations in respect of earthquakes inside or possibly within ten degrees of the Antarctic Convergence. It is envisaged that the bulletins would be similar in form to bulletins issued by regional seismological organizations in other parts of the world, possibly modified as a result of recommendations from the ISS Committee. It is hoped that, as a consequence of such considerations, it may be possible to place a more specific proposal before the next meeting of SCAR.

Upper mantle project

That attention be drawn to a resolution of the XIIth General Assembly of the IUGG that, during the next three years at least, substantially increased attention be paid to problems of the Earth's upper mantle, i.e. the outermost 100 km. or so of the Earth. This resolution bears significantly on research in Antarctica as in other regions of the Earth. It is consequently desirable for National Committees on Antarctic Research to give special consideration to geological, volcanological and seismological research, including explosion seismology, to boring projects, to the study of thermal and chemical problems of the solid Earth, and to problems of geomagnetism including palaeomagnetism. In due course, more specific projects may be proposed, in line with programmes as they develop in other regions, so that Antarctic research can play its appropriate part in the global coverage.

Gravity

(*a*) that reference pendulum stations be established along the coasts of Antarctica for calibration and control of gravity meters.

Working Group on Oceanography (Chairman, Dr M. M. Somov)

(*a*) That countries interested in the Antarctic should provide special time and facilities in their ships for oceanographic work, or send special oceanographic research ships to the Antarctic Ocean;

(*b*) that the need for studying the whole water column from surface to bottom should be emphasized;

(*c*) that repeated observations along 20° E., 165° E., and across the Drake Strait, or along meridians as near as possible to these should be made;

(*d*) that the importance of making direct current measurements at all depths in the Antarctic Ocean should be stressed;

(*e*) that the need for more information about the water conditions near the Antarctic continent in winter should be emphasized;

(*f*) that it would be valuable to have regular information about sea ice, shelf ice and outflowing glaciers from aerial photographs, and that aircraft or helicopters be kept for this purpose. It recommends authorities using weather satellites to try to get high-altitude pictures of ice distribution;

(*g*) that a search be made for evidence of the effect of seismic sea waves on the breaking off of coastal ice;

(*h*) that the need for more detailed study of the natural movements of ice shelves in relation to tides and long waves should be emphasized;

(*i*) that the programme should be planned to give full opportunity for biological, geological and meteorological research;

(*j*) that a small working group be formed to co-operate with SCOR, and exchange of representatives between national SCAR and SCOR committees be encouraged, to promote as much co-operation as possible. It asks National Committees to publish their plans as early as possible;

(*k*) that the co-operation of SCAR member nations with SCOR during the coming Indian Ocean Programme should be recommended, also that increased Antarctic Oceanographic research should be conducted in the appropriate areas during the period of this programme, particularly during 1962–64.

Working Group on Biology

(*a*) That the special problems of the conservation of nature on sub-Antarctic islands should receive further consideration before recommendations are made to the responsible governments;

(*b*) that an International Symposium on Antarctic Biology be held in about two years time;

(*c*) that member nations be urged to implement the SCAR programmes in marine and terrestrial biology;

(*d*) that a Permanent Working Group on Biology be formed, that a permanent Secretary of the group be appointed, and that Dr R. Carrick occupy that office. It instructs the Secretary of the working group:

(i) to collect further information on nature conservation in the sub-Antarctic islands, and to prepare documents for the next meeting of SCAR;
(ii) to draft and circulate a leaflet on preservation of wild life to all persons landing in Antarctica;
(iii) to collect the necessary information for designation of sanctuaries.

The final Plenary Session, after discussing a comprehensive report from the working group, recommended that the report on the Conservation of Nature should be accepted subject to approval by National Committees, and that the Secretary should circulate the report with the request that comments should be submitted by the end of 1960. The need to inform governments of the proposals for the conservation of nature in Antarctica as soon as possible was stressed, in view of the forthcoming meeting of a working group of the Antarctic treaty powers. Reluctance to do this officially before National Committees had been able to express their views on the proposals was also voiced, since it was very desirable that any recommendations made to governments should be in their final form. However, it was strongly recommended that National Committees should see that the appropriate government representatives were aware of the steps being taken by SCAR on the Conservation of Nature in Antarctica. Such contact with government representatives should be on an informal basis until the SCAR proposals on the conservation of nature are confirmed by the Executive Committee, after consulting National Committees and the SCAR Working Group on Biology.

SCAR proposals on the conservation of nature, when confirmed by National Committees, will be published in the *SCAR Bulletin*.

Working Group on Communications (Chairman, A. H. Sheffield)

(*a*) That the Radio Communications Working Group be known as the Communications Working Group;

(*b*) that the function of the Communications Working Group be defined as:

To advise on the practical aspects of communication within the Antarctic, and between the Antarctic and the rest of the World, because of the importance of this problem to Antarctic research;

(*c*) that the attention of all Antarctic radio operators be drawn to the necessity for following the internationally agreed procedures incorporated in the International Regulations, especially with regard to the inclusion in telegrams of an appropriate preamble to all messages;

(*d*) that the Australian Ionospheric Prediction Service and the Argentine Ionospheric Laboratory be invited to distribute to members of the Communications Working Group copies of their propagation forecasts;

(*e*) that radio communication tests should be carried out from 12 September 1960

"Base Roi Baudouin" will attempt to receive the FICOL broadcasts from Port Stanley, and will relay them to Mawson; Mawson will relay the broadcasts to "NAF McMurdo". "Lazarev" will attempt to receive the FICOL broadcasts, and will relay them to "Mirnyy". "Mirnyy" will intercept the transmissions from "Base Roi Baudouin" and Mawson if reception of the FICOL broadcast at "Lazarev" fails;

(*f*) that the list of stations in § V of the *IGY Antarctic Radio Manual* may be brought up-to-date, members of the Communications Working Group should prepare and send to the Chairman of the group, to reach him before 15 October 1960, complete revised lists in the form of those in the *Manual*. Any subsequent amendments to the lists should be included in the Annual Reports on logistics submitted by members of SCAR. If there are no changes, this should be stated;

(*g*) that, in order to ensure that all delays in transmission of messages are investigated immediately, and all failures of the Antarctic communication network are rectified in the shortest possible time, a member of the staff of the International Antarctic Analysis Centre shall be nominated to supervise the operation of the network. It shall be his duty to investigate all failures and to send telegrams to the Antarctic station concerned. If a remedy cannot be found within a reasonable period a report should be sent to the Chairman of the Communications Working Group, with a copy to the representative on the Group of the member of SCAR responsible for that station. Base leaders are reminded of the necessity to exercise constant supervision over the recording and reporting of scientific observations, and the telegraphic transmission of data according to the appropriate priorities;

(*h*) that SCAR notes with satisfaction that arrangements are being made by the United States and Australia to establish a radio teletype link between "NAF McMurdo" and Sydney, and that the circuit is expected to be operational within a month. SCAR also notes that Australia contemplates the establishment of a main trunk radio teletype link between "Wilkes" and Australia and that it is possible that with the establishment of a regular radio teletype link between "NAF McMurdo" and "Wilkes", "Wilkes"–Australia could become the main or alternate route for exchange of meteorological traffic between Antarctica and Australia.

Working Group on National Reports (Chairman, Professor J. van Mieghem)

(*a*) That the National Reports be available each year not later than 30 June in order to allow each Reporter to compile an accurate discipline report, in time for the SCAR meeting, and in order that each participating country in Antarctic research should be informed in due time of the future plans and the completed programmes of the others;

(*b*) that *SCAR Circular*, No. 30, issued on 2 July 1959, be used as a rough guide in drafting the National Reports.

In principle these reports should mention the following items for each discipline;

(i) station location,
(ii) type of observation,
(iii) type of instrument,
(iv) comments.

They should also contain a one page summary in tabular form showing which disciplines have been, or will be, studied, at each base.

(*c*) that the report on completed programmes should contain a full bibliography of scientific publications on Antarctic research carried out by the country during the period covered by the report. Moreover, this report should indicate for each station

and each discipline, type and form of data available from scientific programme conducted during the previous year, and give name and address of responsibl authorities;

(*d*) that concise reports be presented:

(i) in tabular form,
(ii) discipline by discipline.

The following suggestion is made with regard to discipline listing:

1. Upper atmosphere physics (ionosphere, aurora and airglow, cosmic rays geomagnetism);
2. Meteorology;
3. Earth Sciences (geomagnetism, seismology, gravity, geology);
4. Geodesy, topography, cartography.
5. Glaciology;
6. Oceanography;
7. Terrestrial biology and medical research;

(*e*) that inside the disciplines, stations be listed as far as possible by geographica latitudes northwards;

(*f*) that reports be published as far as possible in approximately a standar format (printed horizontally), e.g. 27 cm. wide by 21 cm. high.

(*g*) that a report on logistic aspects of activities of the coming year be publishe as a separate document along lines to be drawn by the Working Group on Logistics

Working Group on Logistics (Chairman, Rear-Admiral D. M. Tyree)

(*a*) That pertinent logistic factors of each Antarctic permanent or semi-permanen installation, as outlined in a specimen form, be circulated to the SCAR nations fo consideration, and that results be circulated by the SCAR secretary, or such part as designated by the SCAR secretary;

(*b*) that considering also the general value of an annual outline from each SCAR nation summarizing their proposed ship movements, air operations and itineraries o inland travelling parties prior to each Antarctic summer programme, such informa tion should be documented and circulated to all SCAR nations as an appendix t the collection of information on logistic support capabilities. The working grou realizes that many plans will of necessity be altered during operations, and urge the transmittal by radio circulars as soon as possible of major changes in plans;

(*c*) that the above information be compiled as soon as possible in order that i may be available for the coming Antarctic summer programme, and that th information be revised annually as necessary;

(*d*) having reviewed a letter by P. G. Law suggesting a symposium to discus all aspects of logistic support, heartily endorses this suggestion and invites con sideration by SCAR nations of the manner in which such a symposium might b brought about during 1961.

Medical science

The Working Group on Biology recommended the circulation of the paper sub mitted by Dr O. G. Edholm and the invitation of comments thereon.

Belgium

Notice has been received from the Belgian delegate that no Belgian party wi winter in the Antarctic during 1961. Belgium will, however, continue to observ her obligations as a member of SCAR.

OBITUARY

Edward G. Bird died at Hawick, Scotland, in June 1959, aged 44. He made several important contributions to knowledge of Arctic ornithology. In 1933 he visited northern Iceland in search of breeding geese. In 1934 he spent two months on Jan Mayen with his brother, Charles Bird, and R. B. Connell; they were able to make a fairly complete survey of the birds of the island. In 1936–37 they spent a year at Myggbukta in east Greenland, using the Norwegian meteorological station as their headquarters. They made a thorough collection of the local birds. During the winter they travelled by dog team and were subsequently able to contribute many useful ideas on sledge dog management at a time when this was a subject of endless discussion and argument among British explorers. During the war he joined the Royal Marines and was mentioned in Despatches for services in Norway. He also took part in the Normandy landings in June 1944. After the war he farmed in Scotland.

Charles Francis Laseron was born in the United States in 1886 and died in Sydney, Australia, on 27 June 1959. He accompanied Sir Douglas Mawson's Australasian Antarctic Expedition, 1911–14, as assistant biologist, and took part in the journey to the Magnetic Pole as well as in several geological surveys along the coast. *South with Mawson*, London, 1947, is his account of the expedition.

Kaptajn Peder Marcus Pedersen, the Danish Greenland navigator, was born on 30 October 1886 and died on 12 August 1959. He obtained his mate's certificate in 1909. Soon afterwards he met Knud Rasmussen and began his long connexion with Greenland and Arctic waters. He was master of *Kap York* and *Søkongen*, and other expedition ships, and took part in the Fifth Thule Expedition, 1921–24. After Rasmussen's death, in 1933, Pedersen held a post in Grønlands Styrelse as ice pilot for a number of years.

Alan Reece was born in London in 1921 and killed in an aircraft accident near Resolute, Cornwallis Island, on 28 May 1960. After service as a naval meteorological officer he joined the Falkland Islands Dependencies Survey in 1944 and, between then and 1947, served at Deception Island, Hope Bay, and at Admiralty Bay. Mount Reece was named after him. In 1949 he obtained his B.Sc. in Geology and soon after joined the Norwegian–British–Swedish Antarctic Expedition, 1949–52, as geologist; his work on the organization of field equipment was of great service to the expedition.

From 1953 to 1956 he worked with the Geological Survey of Uganda, and was awarded his Ph.D. at Imperial College in 1958. During the summers of 1956 and 1957 he worked as field geologist in east Greenland for Nordisk–Minselskab A/S. In 1959 he joined the prospecting firm of J. C. Sproule and Associates in Canada. At the first International Symposium of Arctic Geology, held at Calgary in 1960, he undertook to compile a general geological map of the Arctic regions on behalf of the symposium. Whilst working at Ellesmere Island, his plane crashed during white-out conditions shortly after helping another plane which had force landed on the sea ice.

Reece was a very hard worker and, although forthright in his opinions, these were so genuine that he soon developed lasting friendships with his companions.

His many friends will recall him as one whose outlook was of the stamp of those who took part in the "heroic age" of Antarctic exploration at the beginning of this century.

G. DE Q. R.

RUDOLF SAND, the Danish barrister, died on 29 March 1960 at the age of 80. As Knud Rasmussen's solicitor, he administered the station at Thule in north-west Greenland from 1924 until it was taken over by the Danish state in 1937. His duties included the sale of the station's products, and the drawing up of a code of laws for the settlement.

HUGH R. THOMPSON died on 6 June 1959 in Toronto at the age of 33. He was born in New Zealand, went to school in Scotland, and joined the staff of McMaster University after having received his Ph.D. at McGill University in 1954. He was a Carnegie scholar at the Arctic Institute of North America, and served as geomorphologist on both the Oxford University Expedition to Nordaustlandet, 1949, and the Canadian Baffin Island Expedition, 1953.

WILLIAM HENRY TRIPP, former Curator of the Old Dartmouth Historical Society and Whaling Museum at New Bedford, U.S.A., died on 29 November 1959. He was born on 16 March 1880. Few men of modern times can have possessed such a detailed knowledge of the New Bedford whaling industry. He worked indefatigably for the restoration and preservation of the last whaling ship, the *Charles W. Morgan*, and acted as master for her final voyage in the 1940's, when she sailed from New Bedford to Mystic, Conn.

ERRATA

SCAR Bulletin, No. 3, 1959

Page 34 (596), line 14. *After* Antarctica; *insert* their relationships to processes over.
Page 34 (596), line 30. *For* 80° W. *read* 80° E.

The *Polar Record*, Vol. 10, No. 64, 1960

Page 13, line 28. *For* 13,00 ton *read* 13,000 ton.
Page 14, line 39. *For* sera sera *read* será será.
Page 14, line 41.
Page 15, line 1.
Page 15, line 4. } *For* Auster *read* Otter.
Page 36, line 12. *For* Wisnes *read* Winsnes.
Page 61, line 23. *For* Theil *read* Thiel.
Page 61, line 39. *For* shelves *read* shells.
Page 95, line 9. *Insert* comma *after* Patrick.

The *Polar Record*, Vol. 10, No. 65, 1960

Page 126, line 3. *For* Anne *read* Ann.
Page 138, line 8. *For* 1931 *read* 1926.

RECENT POLAR LITERATURE

This selected bibliography has been prepared by R. J. Adie, Julia Allen, Terence Armstrong, T. H. Ellison, Amorey Gethin, J. W. Glen, W. B. Harland, H. G. R. King, and Brian Roberts. Its main field is the polar regions, but it also includes other related subjects such as "applied" glaciology (e.g. snow ploughs and ice engineering). For the literature on the scientific study of snow and ice and of their effects on the earth, readers should consult the bibliographies in each issue of the *Journal of Glaciology*. For Russian material, the system of transliteration used is that agreed by the U.S. Board on Geographic Names and the Permanent Committee on Geographical Names for British Official Use in 1947 (see *Polar Record*, Vol. 6, No. 44, 1952, p. 546).

Reprints of "Recent Polar Literature". from Nos. 37/38 onwards, can be obtained separately (to allow references to be cut out for pasting on index cards) from the Institute, price 2*s*. 6*d*. for two prints. Copies will be sent without charge to organizations with which the Institute maintains exchange arrangements and which notify their wish to receive them. Readers can greatly assist by sending copies of their publications to the library of the Institute.

To increase the usefulness of the bibliography entries have been arranged provisionally under subject headings in classified order according to the Universal Decimal Classification.

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